AN

IDEA

OF

Geography and Navigation.

CONTAINING

Easie Rules for finding the Latitude and difference of Longitude of Places by Observation of the Sun, Moon and Stars. The demonstration and use of the Log-line. The variation of the Compass. The Doctrine of Plain Triangles. The Construction and use of all manner of Mapps and Charts. To keep a Journal and to work a Traverse both by Plain and *Mercators* Sayling. The Solution of all Nautical questions, Geometrically, Arithmetically, and Instrumentally.

ALSO

Tables of the Sun's Declination and Right Ascension for ever. A Table of the most Eminent fixed Stars in both Hemispheres, rectified for the Year 1700, with their use, and other Tables necessary in Navigation.

By SAMUEL NEWTON, *Master of the Math. School at* Christ's Hospital, *Founded by King* CHARLES II.

LONDON,

Printed for *Christopher Hussey*, at the *Flower-de-Luce* in *Little Britain*.

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To the Right Worshipfull

Sir *JOHN MOORE*, President,

NATHANIEL HAWS, Esq; Treasurer:

And to the Rest of the Worshipful Governors of

Christs-Hospital London.

THIS Manual con-taining the Principles of Geography and Na-vigation, which I composed for the use of my private School, without the least thought of ever making it publick, has at last

quitted its Retirement, and flies to your Worships for Protection. I must confess it is somewhat too early for its appearance abroad, because I wanted time to give it those finishing Strokes which might have rendred it pleasant as well as useful. However seeing its method is plain and easie, it will be of use to me in the service of Christs-Hospital, *and will save the Children of King* Charles *his Royal Mathematical Foundation, a great deal of time and pains in transcribing those Rules contained in it. By your kind Reception of it, I am bold to*

think it will advance daily: And tho' it now appears in puris Naturalibus, *it may afterwards become far more Correct and Perfect. I am*

Your Worships

Christi-Hospital June 28. 1695.

Most Faithful Servant

Samuel Newton.

TO

think it will advance daily: And that as it now appears in puris Naturalibus, it may afterwards become far more Correct and Perfect. I am

Your Worships

Most Faithful Servant

Samuel Newton.

TO

TO THE READER.

THis Piece was Composed in so much haste, that as soon as I had finished the Composure of each Sheet, so much as I had composed was immediately hurry'd to the Press; and many times before I had deliberately consider'd it. So that I can no wayes excuse it from many Imperfections, nor affirm it to be so correct as I had at first designed it. As you will find (through my too much haste) in Page 90. where speaking concerning the way of discovering dif-

difference of Longitude by *Automatas*, it runs thus, *viz.* the farther you advance within the Artic or Antartic Circles, towards either of the Poles, the motion of the Clock shall be so much slower than at *Lond.* Nay the motion thereof shall be retarded tho' you encrease the Weight; and consequently when these correct Automatas are carried into an Air more warm than that in which they were made, their motion shall be swifter than before. This Paragraph ought thus to be corrected; *that the farther you advance towards either Pole, their motion is swifter; and the farther they are carried towards the Equator, their motion is retarded*: I have little else to say to my Reader, for why should I by a needless Address to him anticipate his opinion of the whole Composure? But am apt to believe that he will find many things explained

with

with ſo much eaſe, and improved ſo exceedingly when compared with other Writers upon this Subject, that he will be forced to confeſs the Inſtructions here are uſeful, and adapted to the meaneſt Capacities; which was the Sole Aim of

S. Newton.

THE

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The Contents.

ERRATA.

PAge 46. *l.* 2. all the three Angles given to find the sides, r. *all the three sides given to find the Angle.* Page 184. *l.* 2. r. *the Ship in West Longitude.*

PROEM.

THAT we may more clearly understand this Art which concerns the motion of a Ship upon the Surface of the Sea, we ought to know the true Figure of this Terraqueous Mass.

Diverse of the Ancients supposed the Figure of the World to be a large extended Circular Plain, like that of a round Table, founded upon a Basis or Pedestal, infinitely continued downwards.

Of this opinion was Lactantius, *and others of the Primitive Fathers:* Anaximander *supposed it to be Cylindrical, like a Drum. But most Philosophers and all Mathematicians in our dayes do affirm it Globular or Spherical.*

And that the Earth is Globular or Spherical they prove by these following Arguments:

1. *The Shadow of the Earth in every Lunar Eclipse, projected to the Moon, appears Circular, which being granted, it necessarily follows, that the Earth from whence this Shadow proceeds, must be every way Circular, that is, Spherical.*

2. *When a Man moves directly North or South, the Pole of the World is elevated or depressed in the proportion, as the distance we move upon the Surface of the Earth, (if Spherical) would require.*

Lastly, *Where-ever we stand upon the Surface of the Earth or Sea, the Horizon does alwayes appear Circular.*

 I pass

Place this in the Room of Page 1.

PROEM.

I pass by the Objection from the height of Mountains. For these Inequalities make as much against the Plain Figure of the Earth, as against the Spherical one, and are less then a drop of water could make upon a Table. For the Compass of the Earth is about 25000 English Miles, and the greatest perpendicular height of Mountains, scarce above 3 Miles, so that Mountains are as nothing in Comparison of the whole Earth.

'Tis true that the Earth and Sea seem plain to our sight, but this is because the Eye being elevated only a Man's height, or about 6 feet above the Horizon, sees only such a small Portion of the Spherical surface of the Earth or Sea, as is contained in a Circle, whose Diameter is about six Miles, and so has no sensible Curvature. And when two Ships sail from one another, the Hulls disappear first by the convex Brow of the Water rising up as it were between them.

To conclude, we have seen divers of our Age, have continued in an Easterly Course, till at last they have arrived without turning back, at the same place from whence the first set forth, which could not be, if the Earth were not of a Spherical Form. Lastly, we see the Heavens themselves and all the Celestial Bodies, do all appear Spherical: Then seeing all these consistent parts of the Universe seem to be Orbicular, why should we fancy our Globe of different Form from the rest?

CHAP.

CHAP. I.

Of Astronomical and Geographical Definitions.

1. IF this Globe of Earth and Sea be circumscribed by a line drawn from N°. to S°. this line shall be a Circle, called the Meridian or N°. and South line: for all those lines which can be drawn upon any Spherical or round Body must necessarily be round lines, called Circles.

2. If this Globe of Earth and Sea be circumscribed by another circular line at right angles to the Meridian, and equally distant from the N°. and S°. points of the Meridian, this line so drawn is called the Equator.

Thus in Figure 1. Let ABCE represent the Meridian line, drawn about the round World, so shall AOE represent the Equator.

3. If a right line be drawn through the Center of the Earth, and continued to the North or South points of the Meridian it is called the Axis of the World.

Thus in Fig. 1. Let B represent the North point, and C the South point of the Meridian, then if there be a right line drawn from B through the Center O, and continued to C, this line BOC is the Axis.

4. The ends of this Axis are called the Poles of the World ; thus B is called the North Pole, and C the South Pole.

Note, all Meridians do meet at the Poles of the World : thus BFC. BGC. BHC. do all meet at the Poles B and C in Fig. 1.

5. That point in the Heavens which is directly over your head is called the Zenith, and that point which is directly under your feet is called the Nadir. Thus in Fig. 2. HÆZNPO. is the Meridian, NP. SP. the Axis of the World, NP the North Pole, SP the South Pole, Æ Æ the Equator, Z the Zenith, and N the Nadir.

6. Wheresoever you ſtand upon the Convex Superfices of the Earth or Sea, and looking round about, you ſee the Heavens and the Earth ſeem to meet, they make a Circle, in whoſe Center you ſtand, this Circle is called the Horizon, as in Fig. 2. HCO repreſents the Horizon, and the Center O, repreſents the Place where the Spectator ſtands.

Geographers for the clearer underſtanding of the Poſition of Places, have invented two terms of Art call'd Latitude and Longitude.

7. Latitude they ſay is an Arch of the Meridian contained between the Zenith and the Equator, or between the Pole and the Horizon. Thus in Fig. 2. If O repreſent the North point of the Horizon, and NP the North Pole of the world, the Arch of the Meridian contained between O and NP is called the Latitude of the Place, and it is always equal to ZÆ, the diſtance of the Zenith from the Equator.

8. Lon-

8. Longitude is an Arch of the Equator contained between the first Meridian and the Meridian of any other Place: Thus in Fig. 1. let ABEC represent the Meridian of the Place propounded; I say the Meridian BIC cuts the Equator in G, there ore the Arch of the Equator AG, shews the difference between the first Meridian AB C and the Meridian of the Place propounded, *viz.* BIC.

Note, Geographers do sometimes (especially upon our Globes) draw the first Meridian over the Azores, because under that Meridian the Sea Compass has no variation or deflexion from the North or South points of the Horizon: But in Maps or Charts they sometimes draw the first Meridian over *Tenariff*, and sometimes over the Metropolis of that Country wherein they were borne: As English-men over *London*, French-men, over *Paris*.

9. All that space of Earth contained between the Equator and the N°. Pole is said to lye in North Latitude: thus in Fig. 2. if the Zenith of any place lye between the Equator and the North Pole, it is said to lye in N°. Latitude, Thus Z the Zenith of the Place C falling between the Equator Æ, and the N°. Pole NP, shews the place at C lyes in N°. Latitude: and the number of Degrees contained between Æ and Z, or NP and O, shews the Degrees of its Latitude. Hence it follows that whereever the N°. Pole is above the Horizon, that place lyes in North Latitude.

10. All that space of Earth contain'd between the South Pole and the Equator, is said to lye in South Latitude, and consequently when the South Pole

Pole is elevated above the Horizon, you are in South Latitude; thus also in Fig. 5. if the Zenith of any place lye between the South Pole and the Equator that place is said to lye in South Latitude. Let the place be C, the Zenith thereof Z, falling between SP the South Pole, and Æ the Equator, shews the place to lye in South Latitude; and the number of Degrees contained between Z and Æ, or between SP and H shews the Degree of Latitude.

Note, Mathematicians divide the circumference of every Circle into 360 equal parts, called Degrees: each Degree into 60 equal parts, called minutes: each minute into 60 Seconds, &c. the reason why they chose 360 before any other number, is because this number contains more aliquot parts than any other, consisting of 3 Figures.

Hence then a Semicircle must contain 180 Degrees, and a Quadrant 90 Degrees: And from this note, and def. 9 and 10, you may observe that the Pole can never be elvated above the Horizon, more than a Quadrant, and consequently the Latitude of places can never exceed 90 Degrees.

11. Difference of Latitude is an Arch of the Meridian, contained between any two given Latitudes. Thus in Fig. 1. if one place lye at K, the other at L, the arch KL is called the diff. Latitude between the two places.

12. Diff. Longitude is an arch of the Equator contained betwen the Meridians of any two places. Thus in Fig. 1. let the two given places be M and I; let BMC be the Meridian of the one, and BIC the Meridian of the other, these two Meridians

cut

cut the Equator at F and G; therefore the arch FG is called the diff. Longit. between the two places.

13. The Meridians Equator and Hori on are called Great Circles of the Sphere, because they divide the World into two equal parts; and the Circles KMIN, LP, are called lesser Circles, because they do not divide the World into two equal, but into two unequal parts. These Circles being less than the Equator, and parallel to it are called Parallels.

14. The Declination of the Sun, or any Star is the number of the degrees that the Sun or Star is distant from the Equinoctial. Then,

If the Sun or Star lye between the Equinoctial and the North Pole, the Declination thereof is called North: but if between the Equinoctial and the South Pole, the Declination thereof is said to be South.

CHAP. II.

To find the Ships Latitude at Sea, by observing the Meridian Altitude of the Sun or Stars.

IN observing the Latitude at Sea, we must always have given the Sun or Stars Meridian Altitude and Declination: and must diligently

mark whither the Sun or Star be to the Northward, or to the Southward of the Zenith, which the Sea Compaſs always ſheweth.

The Meridian Altitude of Sun or Star is the Number of Degrees which the Sun or Star is diſtant from the Horizon upon the Meridian: and this number of Degrees ſubtracted from 90°. co/ leaves the diſtance of the Sun or Star from the Zenith.

To conceive, the reaſon or various operations in Aſtronomical Obſervations, you muſt protract the ſame according to theſe following inſtructions, and then it will appear. That

1. If the Sun hath N°. Dec. the Equinoctial muſt be to the Southward of the Sun: and if the Sun hath S°. Dec. it muſt be placed to the Northward of the Sun.

2. If you find the N°. Pole in your Figure above the Horizon, you are in N°. Latitude: if the South Pole be above it, you are in South Latitude.

3. The N°. or S°. Pole is alwayes 90°. diſtant from the Horizon.

4. The Zenith is always ſo many Degrees diſtant from the Equinoctial as the N°. or S°. Pole is from the Horizon.

In the following Figures HZON repreſents the Meridian: Z, the Zenith, N the Nadir. HCO the Horizon. ÆÆ the Equinoctial. NP the N°. Pole. SP the S°. Pole. H the South point of the Horizon. O the N°. point thereof. A the Sun in N°. Dec. B the Sun in South Dec. HA, or HB the Sun's Meridian Altitude. ZA or ZB the Compt. thereof, or diſtance of the Sun from the

Zenith.

Zenith. NPA the Compt. of the Sun's N°. Dec. SPB the Compt. of the Sun's South Dec. ONP (alwayes equal to ZÆ) the Latitude or height of the Pole above the Horizon.

PROB. 1. Fig. 2.

The Sun or Star having no Declinat.

A Ship at Sea, March 10th. 1694. *observes the Sun upon the Meridian to the Southward of the Zenith* 50° 00'. *I demand her Latitude.*

Strike a Circle and Cross with two Diameters HO. ZN at right angles through the Center C, then because (in the Example) the Sun hath no Dec. and is to the Southward of the Zenith, set the Sun's Meridian Altitude from H to Æ: draw the Line ÆCÆ to represent the Equinoctial: then draw NP, SP at right angles to ÆCÆ. It is evident from the Figure that if the Sun (being in the Equinoctial) be upon the Meridian to the Southward of the Zenith, the N°. Pole must be to the Northward thereof: and by the third Rule of this Chap. must be 90 Degrees distant from the point Æ: therefore NP is the N°. Pole, and being elevated above the Horizon, shews the Ship to be in N°. Latitude. Therefore,

From HZ 90° 00'
Subtr. HÆ 50 00

Remains ÆZ 40 00. equal to NPO the Ship's N°. Latitude.

PROB.

PROB. 2. Fig. 3.

The Sun or Star being in the Zenith.

A Ship at Sea, June 10th 1694. *observes the Sun upon the Meridian in the Zenith. I demand her Latitude.*

By Rule 1. of this Chap. ſet the Sun's Dec. *viz.* 23°.30′ N°. from Z to Æ, and draw the Equinoctial ÆCÆ, and NPC, SP at right angles to it, then from Rule 4*th.* it is plain that ZÆ is equal to ONP, but ZÆ is 23°. 30′ therefore the Latitude ONP is 23°. 30′ and becauſe NP is above the Horizon, therefore the Latitude is N°.

PROB. 3. Fig. 4.

The Sun or Star having N°. Dec. and upon the Meridian to the Southward.

A Ship at Sea, May 13. 1694. *obſerves the Sun upon the Meridian to the Southward 58°. high. I demand her Latitude.*

Set the Sun's Meridian Altitude from H to A, and the Sun's Declinat. by Rule 1. from A to Æ, draw ÆCÆ for the Equinoctial, and NPC. SP at right angles to it: then becauſe the Sun's Declinat. is North, he muſt be nearer to the N°. Pole, *viz.* NP, than he is to the South Pole, *viz.* SP therefore

To

To the Sun's Co. Altitude ZA	32°	00'
Add the Sun's Dec. North AÆ ——	20	51
The Sum is ZÆ —— —— ——	52	51

equal to NPO the Ship's N°. Latitude.

PROB. 4. Fig. 4.

The Sun having South Declination, and upon the Meridian to the Southward.

A Ship at Sea, Dec. 10th. 1694. *observes the Sun upon the Meridian to the Southward* 21°. *high. I demand her Latitude.*

Set the Sun's Meridian Altitude from H to B, and by Rule 1. his Dec. 23°. 30' South from B to Æ, draw the Line Æ Æ, and NP. SP at right angles to it, so shall NP, or the North Pole be above the Horizon. Therefore,

From the Sun's Co. Altitude BZ	79°	00'
Subtr. Sun's S°. Dec. BÆ ——	23	30
The Remainer is ÆZ —— —— ——	55	30

equal to ONP the Ship's Latitude N°.

PROB 5. Fig. 5.

The Sun having N°. Dec. and upon the Meridian to the Northward.

A Ship at Sea, May 13. *observes the Sun upon the Meridian to the Northward of her Zenith* 58°. *high. I demand her Latitude.*

Set the Sun's Meridian Altitude from O to A, and by Rule 1. of this Chap. his Dec. from A to Æ draw

Æ draw Æ Æ, and NP. SP at right angles to it, so shall SP be above the Horizon; therefore by Rule 2d. of this Chapter, the Ship is in South Latitude.

From the Co. Altit. Z A	32°	00′
Subtr. the Sun's Dec. N°. Æ A	20	51
The Remainer is ZÆ	11	09 equal

to HSP the Ship's South Latitude.

PROB. 6. Fig. 6.

The Sun having South Dec. and upon the Meridian to the Northward, near the Horizon.

A Ship at Sea, Dec. 10th. 1694. *observes the Sun upon the Meridian to the Northward* 12°. *high. I Demand her Latitude.*

Set the Sun's Altitude from O to B, and by Rule 1. of this Chap. his Dec. from B to Æ; draw ÆÆ and NP. SP at right angles to it: so shall SP be above the Horizon. Therefore,

To the Sun's Co. Dec. SPB	66°	30′
Add his Merid. Altit. OB	12	00
The sum is SPO	78	30 equal

to ZÆ the Ships South Latitude.

PROB.

PROB. 7. Fig. 7.

The Sun having South Dec, and upon the Meridian to the Southward, near the Zenith.

A Ship at Sea, Dec. 12. 1694. *observes the Sun upon the Merid. to the Southward* 78°. *high. I demand her Latitude.*

Set the Sun's Altitude from H to B, and by Rule 1. his Dec. from B to Æ, draw ÆÆ, and NP. SP at right angles to it, so shall SP (or the South Pole) be above the Horizon. Therefore,

From the Sun's S°. Dec BÆ	23°	30′
Subtr. his Co. Altit. BZ —	12	00
Remainer is ZÆ —— —	11	30 equal

to SPH the Ship's South Latitude.

PROB. 8. Fig. 4.

To find the Ship's Latitude by the Stars.

A Ship at Sea, observes Lyra upon the Meridian to the Southward 58°. *high. I demand her Latitude.*

Set the Meridian Altitude from H to A, and because this Star hath N°. Dec. set its Dec. from A to Æ, draw ÆCÆ, and NP. SP at right angles to it: then it is evident the Ship is in North Latitude. Therefore as in Prob. 3.

To the Star's Co. Altitude ZA	32°	00′
Add the * North Decl. AÆ	38	32
The summ is ZÆ —— ——	50	32

equal

Æ draw ÆÆ, and NP. SP at right angles to it, so shall SP be above the Horizon; therefore by Rule 2d. of this Chapter, the Ship is in South Latitude.

From the Co. Altit. Z A	32°	00′
Subtr. the Sun's Dec. N°. ÆA	20	51
The Remainer is ZÆ	11	09 equal

to HSP the Ship's South Latitude.

PROB. 6. Fig. 6.

The Sun having South Dec. and upon the Meridian to the Northward, near the Horizon.

A Ship at Sea, Dec. 10th. 1694. *observes the Sun upon the Meridian to the Northward* 12°. *high. I Demand her Latitude.*

Set the Sun's Altitude from O to B, and by Rule 1. of this Chap. his Dec. from B to Æ; draw ÆÆ and NP. SP at right angles to it: so shall SP be above the Horizon. Therefore,

To the Sun's Co. Dec. SPB	66°	30′
Add his Merid. Altit. OB	12	00
The sum is SPO	78	30 equal

to ZÆ the Ships South Latitude.

PROB.

PROB. 7. Fig. 7.

The Sun having South Dec. and upon the Meridian to the Southward, near the Zenith.

A Ship at Sea, Dec. 12. 1694. *observes the Sun upon the Merid. to the Southward* 78°. *high. I demand her Latitude.*

Set the Sun's Altitude from H to B, and by Rule 1. his Deç. from B to Æ, draw ÆÆ, and NP. SP at right angles to it, so shall SP (or the South Pole) be above the Horizon. Therefore,

From the Sun's S°. Dec BÆ	23°	30'
Subtr. his Co. Altit. BZ —	12	00
Remainer is ZÆ —— —	11	30 equal

to SPH the Ship's South Latitude.

PROB. 8. Fig. 4.

To find the Ship's Latitude by the Stars.

A Ship at Sea, observes Lyra upon the Meridian to the Southward 58°. *high. I demand her Latitude.*

Set the Meridian Altitude from H to A, and because this Star hath N°. Dec. set its Dec. from A to Æ, draw ÆCÆ, and NP. SP at right angles to it: then it is evident the Ship is in North Latitude. Therefore as in Prob. 3.

To the Star's Co. Altitude ZA	32°	00'
Add the * North Decl. AÆ	38	32
The summ is ZÆ —— ——	50	32

equal

equal to NPO the Ship's N°. Latitude required.

Hence it appears that all observations of the Ships Latitude at Sea, taken by the Sun or Stars, are to be wrought by the same rules.

PROB. 9. Fig. 4.

Having the Latitude of any place given, to find the Sun's Meridian Altitude in that place, for any day in the Year.

The Latitude of Lond. *being* 51°. 32′ *N°. I demand the Sun's Meridian Altitude there, upon the* 10th *of* June.

Set the Latitude from O to NP, and draw NP. SP, and ÆCÆ at right angles to it; then set the Sun's Dec. for *June 10th.* viz. 23°. 30′ North from Æ to A, so shall H A be the Sun's Meridian Altitude required, Therefore,

To Co. Latitude H Æ	38°	28′
Add the Sun's N°. Dec. ÆA	23	30
Sum is H A ————	61	58

The Sun's Meridian Altitude for the day required at *Lond.*

And thus also may you find the Meridian Altitude of any Star, in any place whose Latitude is known.

CHAP.

CHAP. III. Fig. 8

Concerning the Quantity of a Degree in a great Circle, upon the Circumference of the Earth.

THE most acute Wits in former Ages have spent much pains in the inquiry after this useful piece of knowledge; else so many Excellent Volumes wrote upon this Subject had not been handed down to Posterity: *Diogenes Laertius* commends *Anaximander*, because he first took this Subject to task, and as Historians tell us, *Anaximander* lived 550 years before the birth of our Saviour: *Eratosthenes* succeeded *Anaximander*, and lived about 200 years before Christ: But the methods he used for the solution of this Proposition, injurious time has deprived us of. *Posidonius* appeared next, who lived some few years before the Incarnation. These excellent Men did industriously endeavour the solution of this Prop. but brought it not to that degree of perfection which succeeding Ages attained to. And from that time to this present Generation we meet with none excepting some *Arabians* and *Saracens* have endeavoured the improvement of it. And in this Century we find the learned *Snellius*, Mathematical Professor at *Leyden*, enquiring into the practice of the

Ancients

Ancients concerning the Quantity of a Degree in a Great Circle upon the Circumference of the Earth; he suspecting their performance, with incredible Industry undertook to determine the Quantity of a Degree, and affirms a Degree contains 28500 Perches, each Perch containing 12 Rinland feet: but a Rinland foot exceeds the English foot by .033, supposing an English foot divisible into 1000 equal parts. Therefore 28500 by 12 produceth 342000 Rinland feet, which multiplyed by 1.033 produceth 353286 English feet, for the Quantity of a Degree required. The proportion between a Rinland and an English foot, I find in Sir *Jonas Moor*'s Fortification and others. But Mr. *Norwood* in his Seaman's Practice, Pag. 34 tells you 96 Rinland Feet make 91 $\frac{1}{2}$ English feet which by this Proportion in Sir, *Jonas Moor*'s should be made 99 $\frac{168}{1000}$, English feet but upon examining Mr. *Norwood*'s following Proportions I find this 91 $\frac{1}{2}$ should be 99. 168 and that the fault lyes in the Printer, not in that Industrious Author.

After *Snellius* we meet with *Tacquet*, who delivers his Opinion of *Snellius*'s Experiment in these words: *Geom. Prac. Lib.* 1. *Cap.* 4. *Prob.* 4. *Cæterum Snellii ista Dimensio non admodum probabilis est, quod ex nimis multis operationibus sit composita, quarum errores singularum simul juncti errorem magnum possunt efficere.* In the next place we find *Ricciolus*, a learned Jesuit, who neither sparing for Money nor time, made the Experiment, and found that a Degree did contain 72 $\frac{1}{2}$ *Bononian* Miles; but a *Bononian* Mile contains 5000 *Bononian* Feet, each *Bononian* Foot containing 1204 parts,

1000

000 whereof make an English foot; therefore 2½ multiplied by 5000, produceth 361250 *Bononian* feet, which multiplied by 1204 produceth 434945000, this divided by 1000, the Quotient is 434945 English feet in a deg. which divided by 5280 the English feet in a mile, gives 82.375 English miles in one degree.

Lastly, Our Country man Mr. *Richard Norwood* made an experiment to this purpose, and found the quantity of a degree of a great Circle upon the surface of the Earth to be 367200 English feet, which is much different from that of *Ricciolus*; and seeing such experiments are not fit to be undertaken at the charge of a private man's fortune, as Mr. *Norwood* intimates; we may conclude that *Ricciolus* his experiment made at the expence of the Jesuits Purse, (he being a member of that Society) was far more exact and certain.

Thus I have given you a brief account of those Famous Men in several Ages, who attempted the discovery of a truth so useful to mankind, I shall now shew you the method some of them made use of, for the performance of it.

FIG. 8.

They first pitched upon two places, both under one Meridian, represented in the Heavens by the Circle BEAFDM, and on the Earth by the Circle GHIKL: the two places we will suppose to be H and I: then by the foregoing Chap. or else by the Circumpolar Stars (far more convenient for the present purpose) they found the

Latitude, or Poles height at both these places, which from the Figure may be easily conceiv'd; thus BCD will be the Horizon of the place at H, and BN may represent the height of the Pole there: and ECM the Horizon of the place at I, so shall EN represent the Latitude of the place I, and N shall be the North Pole. Then with all possible exactness they measured the distance of these two places, *viz.* the Arch HI, and by subtracting the lesser Latitude EN, out of the greater BN, the remainer is BE their diff. Latitude: then because BA, and EF are both Quadrants, therefore BE shall be equal to AF; thus the two Arches AF, in the Heavens, and its responding Arch HI on the Earth are both known: for by measure the Arch HI was found to contain 121. $\frac{704}{1000}$ miles, and the diff. Latit. or responding Arch in the Heavens, *viz.* AF was 1°. 45'. and these two Arches AF. HI are like by 33. 6. Euc. therefore, as 1°. 45'. is to 121. 704 miles, so is 360 (the degrees in the circumference of any Circle) to 25036. $\frac{36}{100}$ miles in the Ambit or Circumference of the Earth, which divided by 360 gives 69. $\frac{548}{1000}$ English miles for the quantity of a degree required.

And thus did Mr. *Norwood* proceed, for first he pitched upon the two famous Cities of this Country, *London* and *York*, and having found as afore the true diff. Latitude between them, he measured their distance asunder, and then by the foregoing proportion discovered the quantity of a degree; only in measuring between them, he did not confine himself to the Meridian, but deviated Eastward or Westward, as occasion offered;

ed, and so by keeping an account in form of a Ships traverse, he found the Meridional distance between the two places.

FIG. 9

Eratosthenes his method was this, he first assumed two places lying under the same Meridian, the one was *Alexandria* in *Egypt*, where he liv'd, the other was *Syene*, a City lying under the Tropick of Cancer, and consequently by Chap. 2. the Latitude thereof was 23°. 30'. North. Hence also by Prob. 2. of Chap. 2. when the Sun came to the first point of Cancer, or (which is all one) when the Declinat. was 23°. 30' N°. which happened upon *June* 17*th* or 18*th*. then he must be in the Zenith of that place, and his Altitude must be 90°. 00'. therefore he took the Sun's Meridian Altitude *June* 18*th* at *Alexandria*, and by Chap. 2. found the Latitude thereof to be 30°. 58'. N°. and consequently the diff. Latit. between these two places to be 7°. 28'. and thus the Celestial Arch contain'd between the Zenith of these two places was discovered: next he measured the distance between them upon the Earth, carefully observing not to deviate from the Meridian under which the two places lay; and thus he found the responding Terrestrial Arch, and then proceeded as afore.

But, the most remarkable circumstance in this Experiment was his method of finding the Sun's Altitude upon the Meridian at these two places, which he did by a Concave Hemisphere with a style erected perpendicular from the concave Nadir point, as CD, upon which the Sun shining from

A, the Ray ECF determined the Meridian Altitude thereof, as GE or HF; and at the same time he found the Co-altitude, or distance of the Sun from the Zenith BE or FD, but at *Syene* the same day, the Sun could make no shadow, because he was in the Zenith therefore he concluded that BE was the true Zenith's distance or diff. Latit. between these two places. &c.

Posidonius his method was this, Fig. 8.

He assum'd two places under the same Meridian, as A representing *Rhodes* where he lived, and F *Alexandria* in *Egypt*. In these two places he observed *Canobus* (or the bright Star in the Stern of the Ship) upon the Meridian, and whether this observation be made upon the same, or upon different days, it matters not. But this Star was not seen above, but only in the Horizon BKD at *Rhodes*, and at *Alexandria* the Meridian Altitude thereof above the Horizon ECM was found to be MD, or 7°. 30′. which is exactly the 48*th* part of 360 degrees; then he measured the :responding Terrestrial Arch LK, and so proceeded as afore.

The excellent *Varenius*, and others give you an account of divers other ways for finding the quantity of a degree upon the Earth, without the help of Astronomical Observations; but most of these being translated into English, I refer the Reader to them, rather than spend more time in transcribing of them.

CHAP.

CHAP. IV.

Of the Log-Line.

DIvers ways have been invented for finding the Ship's motion at Sea; but the most usual way is by the Log-line.

It is taken for granted amongst our English Mariners that when this Log is cast over board, (with sufficient allowance for stray-line) it remains quiescent upon the surface of the Sea: the line to which the Log is made fast, they usually divide into certain equal spaces called knots, each 42 foot distant from other: and then by help of a Glass, which ought to contain ½ a minute, they find how many knots the ship runs away from the Log in that quantity of time: and then they conclude, that if the Ship runs out one knot in ½ a minute, she runs one mile each hour: and 60 of these miles they suppose to be a Degree upon the surface of the Earth or Sea. But before we take this supposition to be true, let us examin it by the rule of reason, whether or no it will endure the Test.

Seeing the Ship's motion depends altogether upon the truth of the ½ minute Glass, we will enquire the way how to find the quantity of an ½ minute, which being repeated as often as you please, will still produce the same.

The fixed Stars move more regularly than any of the Superiour Bodies, and their Equatorial motion is 1. degree for every 4 minutes in time: therefore if we find any two Stars whose difference in right aſcenſion is 30′. the Center of one of theſe Stars being upon the Meridian, the Center of the other ſhall come upon the ſame Meridian in ½ a minute's time after the other. As thus, if the little Star in the Eduction of the Crane's Tayle (whoſe right aſcenſion for the year 1700) is 33 6°. be upon the Meridian, the Southern of the two in the Breaſt of Pegaſus, (whoſe right aſcenſion for the ſame year is 336) ſhall come upon the ſame Meridian 8 minutes after. Therefore their Equatorial diſtance in time, being 8 minutes, we are to find ſome particular method for meaſuring this or any other quantity of time, which is moſt exactly done by the Vibrations of a Pendulum, which may be demonſtrated to be Equitemporal.

Experience confirms this Truth, that if there be a Pendulum whoſe length (from the Center) is 39. 2 inches, it vibrates Seconds, or ſixty times in a minute; therefore for the tryal of your ½ minute Glaſſes, ſet one of theſe Pendulums in motion, and at the ſame time turn the Glaſs; and if the Glaſs be true, the Pendulum ſhall vibrate or croſs the Perpendicular juſt 30 times before the Glaſs be run out: but moſt of thoſe Glaſſes now us'd by our Seamen, ſeldom contain more than 25, or 26 Seconds: hence it is evident, their Glaſſes do not contain a true ½ minute.

And if you would find the quantity of time meaſured

measur'd by any other Pendulum whose length is greater or lesser than 39. 2 Inches, this is.

The Rule.

The length of Pendulums are to each other reciprocally as the Squares of their vibrations in the same time.

Thus, if a Pendulum 39. 2 inches long, vibrate, or cross the Perpendicular 60 times in a minute, how oft will a Pendulum 15. 5 inches vibrate in the same quantity of time. Say if 15. 5 inches, require 39. 2 inches, what shall 3600 (the square of 60 Seconds) require. Answer, the fourth proportional number is 9105, whose square root 95 gives the number of vibrations or swings that Pendulum shall make in one minute.

The demonstration whereof you may see more at large in *Kercher's Mundus Subterran. Ricciolus, Galileo*, and Mr. *Molineux* in his *Scioth. Telescopic.*

Thus it is evident the common ½ minute Glasses are false: we will next enquire into the Division of the Log-line, where each knot is 42 foot distant from other.

An English mile contains 8 Furlongs, each Furlong 11 Scores, and every Score 20 yards. So that a Statute mile contains 1760 yards, or 5280 English feet. Then seeing there are 120 half minutes in an hour, there ought to be 120 times 42 feet in a mile; but 120 multiplied by 42 produceth only 5040 feet, so that by this computation, they make only 5040 feet in a mile, which is 249 feet shorter than it ought to be: thus it appears that not 42, but 44 feet answer to the 120th part of an English mile: and conse-

ſequently, both the common Glaſs and Diviſion upon the Line are erroneous.

And becauſe our Seamen are not eaſily perſwaded to leave any old cuſtom; we will continue the ſame Glaſs and diviſion of the Log-line, and yet find the Ship's true motion thereby

For the performance whereof you muſt examine the quantity of your ½ minute Glaſs, by a Pendulum of 39. 2 inches long: the weight appended being about one pound, and if you find this Glaſs to contian 25,26, or any other number of Seconds. Say,

If 25 Seconds require 42 feet, what ſhall 3600 Seconds require? Anſwer 6040 feet. Again,

If 26 (or any other number of Seconds) require 42 feet, what ſhall 3600 (the Seconds in an hour) require? Anſwer 5815 feet: hence it appears that the ſhorter the Glaſs, the longer is the Ship's diſtance: and the contrary; thus if the Glaſs contain 30 Seconds, the Ship's diſtance run will be 5040 feet each hour.

To apply this to our preſent purpoſe, I told you in the foregoing Chapter, that a Degree in a great Circle (upon the ſurface of the Earth) did contain (by Mr. *Norwood*'s Experiment) 69.54 miles, or 367200 Engliſh feet: and ſeeing our Seamen do uſually divide a Degree into 60 equal parts, called miles, or minutes, every of these parts muſt be greater than an Engliſh mile: therefore if you divide 367200 by 60, the Quotient 6120 will be the number of Engliſh feet contained in one of theſe Sexagenary miles Then if the Glaſs contain 25 Seconds, and the diſtance between any 2 knots be 42 foot; it is evident that the

[th]e Ship runs away from the Log-board 42 foot [i]n 25 Seconds of time, ſhe muſt run 6040 foot [in] 3600 Seconds or one hour's time, that is the [S]hip muſt run $\frac{6040}{6120}$ of a mile, 60 whereof make [a] Degree. But this vulgar Fraction may be re-[d]uced into a Decimal Fraction, by this following [p]roportion, *viz.*

If 6120 require 1000, what ſhall 6040 require? [A]nſwer, 986, which being the Decimal parts of [a] mile which the Ship is ſuppos'd to move in one [h]our, when the Glaſs contains 25 Seconds; we [m]ay make a Table to ſhew by inſpection the num-[b]er of miles run by the Ship, for any number of [K]nots, *viz.* by the continual addition of 986, or [b]y multiplying it by all the 9 Digits.

And becauſe all Glaſſes are not of a like con-[t]ent, and that every Seaman is not acquainted with Decimal Arithmetick, I have here added theſe following Tables.

TABLES

Tables for finding the Ship's true motion at Sea, by the Log knots being 42 feet asunder, for all Glasses from 23 Seconds to 30 Seconds

Glass 23 Seconds.				Glass 24 Seconds.			
Knots	Miles & 1000 parts.	Fathō.	1000 pts of a mile	Knots	Miles & 1000 parts	Fathō.	1000 pts of a mile
1	1. 074	1	107	1	1. 029	1	103
2	2. 148	2	214	2	2. 058	2	206
3	3. 222	3	322	3	3. 087	3	309
4	4. 296	4	429	4	4. 116	4	411
5	5. 870	5	537	5	5. 145	5	514
6	6. 444	6	644	6	6. 174	6	617
7	7. 518	7	752	7	7. 203	7	720
8	8. 592	8	859	8	8. 232	8	823
9	9. 666	9	966	9	9. 261	9	926
10	10.740			10	10.290		

Glass 25 Seconds.				Glass 26 Seconds.			
1	0. 987	1	.98	1	0. 950	1	.95
2	1. 974	2	196	2	1. 900	2	190
3	2. 961	3	294	3	2. 850	3	285
4	3. 948	4	392	4	3. 800	4	380
5	4. 935	5	490	5	4. 750	5	475
6	5. 922	6	588	6	5. 700	6	570
7	6. 909	7	686	7	6. 650	7	665
8	7. 896	8	784	8	7. 600	8	760
9	8. 883	9	882	9	8. 550	9	855
10	9. 870			10	9. 500		

Glass

Glass 27 Seconds				Glass 28 Seconds.			
Knots	Miles & 1000 parts.	Fathoms	1000 parts of a mile	Knots	Miles & 1000 parts.	Fathoms	1000 parts of a mile
1	. 915	1	91	1	0.882	1	88
2	1. 830	2	183	2	1.764	2	176
3	2. 745	3	274	3	2.646	3	264
4	3. 660	4	366	4	3.528	4	353
5	4. 575	5	457	5	4.410	5	441
6	5. 490	6	549	6	5.292	6	529
7	6. 405	7	630	7	6.174	7	617
8	7. 320	8	732	8	7.056	8	705
9	8. 235	9	824	9	7.938	9	794
10	9. 150			10	8.820		
Glass 29 Seconds				Glass 30 Seconds.			
1	0. 852	1	85	1	0. 823	1	82
2	1. 704	2	170	2	1. 646	2	164
3	2. 556	3	255	3	2. 469	3	247
4	3. 408	4	341	4	3. 292	4	329
5	4. 260	5	426	5	4. 115	5	411
6	5. 112	6	511	6	4. 938	6	494
7	5. 964	7	596	7	5. 761	7	576
8	6. 816	8	682	8	6. 584	8	658
9	7. 668	9	767	9	7. 407	9	741
10	8. 520			10	8. 230		

The use of these Tables.

WHen the Glass is 23 Seconds, if the Ship runs out one knot in the time of one Glass, she must run 1. 074 mile an hour, if two knots, she runs 2 miles and $\frac{148}{1000}$ parts of a mile in one hour :

hour: and so for more knots, she must run more miles. and thousand parts of a mile *per* hour. The same you must understand of all the other Tables, according to the length of the responding Glasses.

But because the Ship doth not always run out even knots, but many times 1. 2. 3 knots and somewhat more, therefore that you may exactly know the Ship's motion, (when she runs more than an even knot) without guessing, I have thought of this following help, *viz.* take a Line equal in length to the distance between any two knots, divide this Line into 10 equal parts, and at each division make so many distinguishing marks, (by pieces of Leather, or several coloured cloth) as there are equal parts in the whole. This line so divided and marked, I call the Fathom-line.

The use of this Fathom-line is thus, when the Ship hath run out more than an even knot, apply this Fathom-line to the nearest knot in the Log-line, so shall this Fathom-line shew the number of Decimal parts of a knot which the Ship hath run more than an even knot. Then in each of the foregoing Log-Tables you have the Millesimal parts of a mile answering to the respective number of Fathoms: Thus, suppose a Ship (by a glass of 25 Seconds) runs out 4 knots and $\frac{8}{10}$, or 8 Fathoms in the space of 25 Seconds;

I demand how many miles and parts she runs in an hour?

In the Table of 25 Seconds, you find against 4 knots, stand 5. 948 miles, and against 8 Fathom in the same Table stand .784, which added

to

o 3. 948 makes 4. 732 miles, or 4 miles and $\frac{732}{1000}$ parts of a mile for the Ship's distance run that hour: and thus you must proceed with any other number of knots and Fathoms, which being very plain and easie, I need not spend more time in adding more Examples.

Thus I have demonstrated that the Ship's motion at Sea depends upon the Glass: for when the Glass contains only 23, or 24 Seconds, the Ship then runs somewhat more than a Sexagenary mile every hour, and when the Glass contains 25, 26, 27, 28, 29, or 30 Seconds, then her motion is less than a mile each hour. Yet our Seamen commonly estimate the Ship runs so many miles every hour, as she runs knots in the time of one Glass, let the Glass be any number of Seconds made at all adventure, and notwithstanding this evident demonstration; it is to be feared that Custom and Prepossession will not suffer them to embrace a Truth so practical, easie and useful.

CHAP.

CHAP. V.

To reduce Sexagenary Miles into English Miles; and the contrary.

IN the third Chapter I gave you an account of some Experiments made for finding the quantity of a degree in a great Circle, upon the superface of the Earth or Sea, where it was demonstrated that $69.\frac{548}{1000}$ English miles answered to a degree. But at Sea we generally allow a degree to be divided into 60 equal parts, therefore 69. 548 divided by 60, the Quotient 1. 159 is the quantity of a Sexagenary mile: Hence it follows that to reduce Sexagenary into true English miles you must

Multiply 1. 159 by the number of Sexagenary miles, that product divided by 1000, the Quotient is the number of English miles required.

And on the contrary, to reduce English into Sexagenary miles, You must

Multiply the number of English miles by 1000 that Product divided by 1. 159 the Quotient gives the number of Sexagenary miles contained in all the given English miles.

Examp-

EXAMPLE.

In 234 Sexagenary miles, *I demand how many* *nglish miles.*

1.159
234

4636
3477
2318

1)271 | 206 | 271 $\frac{206}{1000}$
000

Thus it appears there are 271 $\frac{206}{1000}$ English iles in 234 Sexagenary miles.

But to reduce English into Sexagenary miles, thus, let it be required to find how many Sexgenary miles there are in 234 English miles.

234
1000

1.159) 234000 (201
2241
10

Answer there are 201 $\frac{1001}{1159}$, Sexagenary miles the number of English miles given.

And thus it is evident, that all distances found y the Ship's motion at Sea, being computed acording to the Sexagenary Division of a Degree, e lesser than they ought to be.

Divers other things might be drawn from the rinciples in these two Chapters, which for brevi- I omit to mention.

CHAP.

CHAP. VI.

The Doctrine of Plain Triangles.

THE whole Art of Navigation consists in the application of Plain and Spherical Triangles. For all questions in Sailing upon the Plain and True Sea Chart, are resolved by Plain Triangles: and all Geographical and Astronomical Problems are drawn from a Spherical Triangle.

DEFINITIONS. Fig. 10.

1. ACB, DCE, being two lines drawn through the Center C, are called Diameters.

2. A right line drawn from the Center C to the circumference of the Circle, is called the Semidiameter or Radius of the Circle; thus CA, CB, CD, CE, are called Semidiameters, or Radii.

3. An Arch is any part of the circumference of a Circle, thus FBI is called an Arch.

4. A Chord is a Right-line drawn from one end of an Arch to the other, thus FKI, is called the Chord of the Arch FBI, and also is the Chord of the Arch FAI, the Complement of the Arch FBI to a Circle.

5. The

5. The right Sine of an Arch, is a right line drawn perpendicularly from the term of that Arch upon the Diameter: or which is all one, the right Sine of an Arch is ½ the Chord of twice that Arch. Thus FB, BI are two equal Arches. FKI is the Chord of these two Arches, and FK ½ the Chord thereof is called the Sine of the Arch FB.

But the sine of an Arch less than a Semicircle, is the sine of the Complement of that Arch to a Semicircle, and thus FK is not only the sine of the Arch FB, but also of its Complement to a Semicircle FDA.

6. If from C the Center of a Circle, through F the term or end of the Arch BF there be drawn an infinite right line, as CFG, and from B the end of the Diameter there be erected the perpendicular BG, and these two lines be continued till they meet at G, the Perpendicular line BG shall be the Tangent of the Arch BF, and the other line CG shall be the Secant of the same Arch.

By these Definitions it is evident that LF is the sine of the Arch DF, and also the sine of its Complement to a Semicircle, *viz.* of the Arch FBE. Also DH is the Tangent of the Arch DF, or the Tangent of the Complement of the Arch BF to a Quadrant. And CM is the Secant of the Arch DF or the Secant of the Complement of the Arch BF to a Quadrant.

The sides of all Plain Triangles are measured by some line of equal parts, as of Leagues, Miles, Poles, yards, Feet, Inches, Barley-Corns, or any other less measure. Thus in Figure the 11. the

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To reduce Sexagenary Miles into English Miles; and the contrary.

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Multiply the number of English miles by 1000, that Product divided by 1. 159 the Quotient gives the number of Sexagenary miles contained in all the given English miles.

Exam[ple]

EXAMPLE.

In 234 Sexagenary miles, *I demand how many English miles.*

$$\begin{array}{r} 1,159 \\ 234 \\ \hline 4636 \\ 3477 \\ 2318 \\ \hline 1)271 \,|\, 206 \,|\, 271\tfrac{206}{1000} \\ 000 \end{array}$$

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$$\begin{array}{r} 234 \\ 1000 \\ \hline 1,159)\ 234000\ (201 \\ 2241 \\ 10 \end{array}$$

Answer there are 201 $\frac{1001}{1159}$ Sexagenary miles in the number of English miles given.

And thus it is evident, that all distances found by the Ship's motion at Sea, being computed according to the Sexagenary Division of a Degree, are lesser than they ought to be.

Divers other things might be drawn from the Principles in these two Chapters, which for brevity, I omit to mention.

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But the sine of an Arch less than a Semicircle, is the sine of the Complement of that Arch to a Semicircle, and thus FK is not only the sine of the Arch FB, but also of its Complement to a Semicircle FDA.

6. If from C the Center of a Circle, through F the term or end of the Arch BF there be drawn an infinite right line, as CFG, and from B the end of the Diameter there be erected the perpendicular BG, and these two lines be continued till they meet at G, the Perpendicular line BG shall be the Tangent of the Arch BF, and the other line CG shall be the Secant of the same Arch.

By these Definitions it is evident that LF is the sine of the Arch DF, and also the sine of its Complement to a Semicircle, *viz.* of the Arch FBE. Also DH is the Tangent of the Arch DF, or the Tangent of the Complement of the Arch BF to a Quadrant. And CM is the Secant of the Arch DF or the Secant of the Complement of the Arch BF to a Quadrant.

The sides of all Plain Triangles are measured by some line of equal parts, as of Leagues, Miles, Poles, yards, Feet, Inches, Barley-Corns, or any other less measure. Thus in Figure the 11. the

line AC is called the Hypothemusal, AB the Base and BC the Perpendicular.

But AC in this Figure is made the Radius or Semidiameter of a Circle, and may be divided into 10, 100 1000, 10000. or any other number of equal parts consisting of an Unite with Cyphers; then by definition the 5th BC will be the sine of the Arch CD, and AB will be the sine of the Arch AE, and these two sines will contain some certain number of equal parts, which must be measured by the same Scale wherewith AC was measured. Again, in Fig. 12. AB is made the Radius or Semidiameter of a Circle, and must be divided into some number of equal parts consisting of an Unite with Cyphers, then by definition 6. BC is the targent of the Arch BD, and AC the Secant thereof, and these two, *viz.* BC, AC must be measur'd by the same Scale wherewith AB the Radius was measured.

7. An Angle is the inclination of two lines the one to the other, as in Fig. 11. the lines CA, BA both meeting in one point A, make an Angle, and the point A where these two lines meet is called the angular point.

Sometimes there are many lines drawn from one angular point, as in Fig. 10. from the Center C, there are drawn the lines CA, CD, CF, CB, and the several Angles proceeding from this point C, are distinguished by three Letters, the middlemost whereof denotes the angular point. Thus the lines CA, CD make an Angle ACD, or DCA: the lines CD, CF make the Angle DCF, or FCD, and the lines CF, CB, make the Angle FCB, or BCF.

8. If

8. If any two lines making an angle, (or meet-g one point) be perpendicular to each other, as e the two lines CA, CD, the angle so made is lled a right angle, as ACD, which is always qual to the fourth part of a Circle or 90°. 00′.

9. An acute angle is always less than a right gle, as FCB, or BCF.

10. An obtuse angle is always greater than a ght angle as ACF, or FCA.

The angles of every Plain Triangle must be easured by a Circle described upon the angular oint. Thus the Quadrant or right angle ACD, ontains 90°. 00′. and when it is known how ma- y degrees are contained in the Arch BF, the easure of that angle is said to be known.

From the foregoing definitions it is evident that ny one of the three sides of a right-angled plain riangle may be made the Radius of a Circle, nd then the other sides will either be both ines as in Fig. 11. or the one a Tangent, and the ther a Secant, as in Figure 12, and these Sines, angents or Secants are called Natural: from hich definitions, the Tables of Natural Sines, angents and Secants took their Original: by elp whereof the Ancients did expedite the so- tion of all Plain Triangles. For when any one de of a right angled Plain Triangle is made the adius of a Circle, and it be known how many arts of that Radius are contained in the o- her sides, the solution of that Triangle is easily xpedited from 4. 6. *Euclid.*

EXAMPLE.

In Figure 11. let the Radius AC contain 100000, nd let the angle CAB (whose measure is the

Arch CD.) be 30°. then shall the angle AC (whose measure is the Arch AE) contain 60°. 00 but these two sides AB, BC are Sines, by defin. therefore in the Table of Natural Sines, find the Sine of 30°. which is 50000, and also the sine of 60°. 00'. which is 86602, then it is evident that seeing CB is the Sine of the Arch CD, CB shall be 50000, and AB 86602, and thus the three sides of this Triangle are known in parts of the Radius, then if the three sides of this Triangle be measured by any other Scale (different from that whereof the Radius AC did contain 100000) the numbers or measures found by both these several Scales shall be proportional 4. 6 *Euclid.*

For let AC by any other Scale contain 246, then if you desire to find the length of the other two sides AB, BC, by the same Scale, Say

If AC 100000 require AC 246, what shall BC 50000 require. Answer 123, BC.

100000—246—50000
50000

123.00000

AC BC

Again, as AC 100000 – 246 —— 86602
246

519612
346408
173204

213.04092

Thus

Thus it is evident that if AC 100000 require AC 246, then BC 50000 will require BC 123, and by the same proportion AB 86602, will require AB 213. The same is to be understood of Tangents and Secants.

And thus the business of Plain Triangles will appear plain and easie:and the solution thereof by Natural Arithmetick, is performed only by Multiplication and Division. And because the practice of Multiplication and Division is very troublesome, and tedious, the renowned *Napier*, Baron of *Marcheston*, has invented certain Logarithmical numbers, called Artificial Sines, Tangents, &c. which perform the business of Multiplication by Addition, and that of Subtraction, by Division.

Thus I have explained the nature of the Mensuration of Plain Triangles, I shall now lay down some other necessary Precognita's, and then proceed.

THEOREM 1. Fig. 14.

If any two right lines cross one the other, the opposite angles shall be equal.

Thus the two right lines AE, BD crossing each other in C, do make the angles ACD, BCE equal to each other.

Demonstr. from C as a Center, strike the Circle FGHI, then shall IFG, GHI be two equal Semicircles, by 18 Def 1. *Euclid.* also FGH, FIG shall be two Semicircles; but all Semicircles having the same Diameters, are equal to each other, and therefore these four are Semicircles mutually equal to each other. D 3 Then

Then if from the Semicircle IFG, you ta[illegible] away the Arch FG, there will remain the Ar[illegible] IF: alſo if from the Semicircle FGH, you take a[illegible] the Arch FG, there will remain the arch GH, ther[illegible] fore if from two equal Semicircles, IFG, FG[illegible] you take away the Arch FG, the two remaini[illegible] arches IF, GH ſhall be equal to each other: b[illegible] IF is the meaſure of the angle ACD, and GH [illegible] the meaſure of the angle BCE; therefore th[illegible] two angles are equal. In like manner it may [illegible] demonſtrated that the angle ACB, is equal to t[illegible] angle DCE.

THEOREM 2. Fig. 15.

If a right line fall upon two Parallels, it makes b[illegible] the alternate Angles equal each to other.

Thus if the right line FH be drawn croſs t[illegible] parallels AB, CD, the angles FEB, EGD ſhall [illegible] equal each to other.

Demonſtr. Seeing that by Hypotheſis the lin[illegible] AB, CD are parallel to each other, and that F[illegible] is a right line croſſing AB in E, and CD in G[illegible] there can be no reaſon in Nature why it ſhou[illegible] incline more to the one, than it doth to the oth[illegible] and if it hath not a greater inclination to t[illegible] one than it hath to the other, then muſt t[illegible] alternate Angles FEB, EGD be equal.

THE[illegible]

THEOREM 3. Fig. 15, 16.

The three angles of any Plain Triangle, are equal to two Right Angles.

IN Fig. 15. from E let fall the Perpend EI, so shall GEI be a right angled Triangle: then by Def. 8. the angle EIG is a right angle, as also is the angle AEI, and this right angle AEI is by the line FH divided into two acute angles AEG, GEI, but by Theorem 1. the angle AEG is equal to the angle EGI, therefore the two acute angles EGI & GEI are equal to a right angle, and the angle EIG is right, therefore the three angles of a right angled Plain Triangle are equal to two right.

Hence it is evident, that if one acute angle in a right angled Triangle be given; if you subtract this acute angle from 90°. the remainer will be the other acute angle.

FIG. 16.

The three angles of an Oblique Plain Triangle are equal to two right.

The lines EG, HK are parallel to each other, therefore by Theor. 2. the angle EAB, is equal to the angle ABC: also the angle GAC is equal to the angle ACB, but the angle EAB is measured by the Arch DF, the angle GAC is measured by the arch IK, and the angle BAC is measured by the arch FK, and these three arches are equal to a Semicircle, therefore the three angles

of any oblique Triangle are equal to a Semicircle or two right angles.

Hence if in any oblique plain Triangle, there be any two of its angles given, the sum of these two given angles subtracted from a Semicircle or 180°. the remainer is the third angle.

AXIOM 1.

In all right-angled Plain Triangles, any of the three sides may be made the Radius of a Circle, and the other sides will be as Sines, Tangents or Secants. And what proportion the side put as Radius hath unto Radius; the same proportion hath the other sides to the Sines, Tangents or Secants of the opposite angles by them represented.

IN Fig. 11. the Hypothenusal AC is made Radius, and therefore the Base AB shall be the Sine of the angle at C, and the perpendicular BC the sine of the angle at A. Then let us suppose the length of the Hypothenusal to be any number of Yards, Feet, Inches, *&c.* and the quantity of the angle at A to be known, and let it be required to find the length of the Perpend. BC in Yards, Feet or Inches, *&c.*

In the Solution of Triangles we must always have three parts given to find a fourth, and the parts given must either be two sides and one angle; or the three angles and one side: or else the three sides.

1. If we have given in a right angl'd Triangle the Hypothenusal AC, and the Angle at A to find the Perpendicular BC, and that the Hypothenusal

thenufal be made Radius: here before we can rightly underftand how to frame a Canon or proportion between thefe three given terms, and the fourth required, we muft confider the nature of thefe three given parts, as, whether they be angles or fides; but we find in this cafe, that the Hypothenufal is a double term, for it reprefents a fide; as being a line confifting of fome number of known parts, as Miles, Yards, Feet, Inches, *&c.* and it alfo reprefents an angle, as being the Radius of a Circle, and fubtending the right angle at B, and fo muft contain fome number of known parts, confifting of 1 and Cyphers, and the third term is an angle. Seeing then we have two terms of one kind, *viz.* both angular, we muft begin with that angular term which relates to the fide given, and then the Proportion will be as Radius AC is to the Hypothenufal AC. So is BC the fine of the angle at A, to the Perpendicular BC.

Again, fuppofe the fame parts to be given and required as afore, and that the Bafe AB in Fig. 12, be made the Radius of a Circle, then from Def. 1. it is evident that BC is the Tangent of the angle at A, and AC the Secant of the fame angle; therefore the angle at A is a double term, having relation both to the fide given AC, and to the fide required BC, and muft thus be ufed, *viz.* As Secant of the angle A, *viz.* AC, is to Hypothenufal AC, fo is Tangent of the angle A, *viz.* BC to the Perpendicular BC.

Laftly,

of any oblique Triangle are equal to a Semicircle or two right angles.

Hence if in any oblique plain Triangle, there be any two of it's angles given, the sum of these two given angles subtracted from a Semicircle or 180°. the remainer is the third angle.

AXIOM I.

In all right-angled Plain Triangles, any of the three sides may be made the Radius of a Circle, and the other sides will be as Sines, Tangents or Secants. And what proportion the side put as Radius hath unto Radius; the same proportion hath the other sides to the Sines, Tangents or Secants of the opposite angles by them represented.

IN Fig. 11. the Hypothenusal AC is made Radius, and therefore the Base AB shall be the Sine of the angle at C, and the perpendicular BC the sine of the angle at A. Then let us suppose the length of the Hypothenusal to be any number of Yards, Feet, Inches, *&c.* and the quantity of the angle at A to be known, and let it be required to find the length of the Perpend. BC in Yards, Feet or Inches, *&c.*

In the Solution of Triangles we must always have three parts given to find a fourth, and the parts given must either be two sides and one angle; or the three angles and one side: or else the three sides.

1. If we have given in a right angl'd Triangle the Hypothenusal AC, and the Angle at A to find the Perpendicular BC, and that the Hypothenusal

thenuſal be made Radius: here before we can rightly underſtand how to frame a Canon or proportion between theſe three given terms, and the fourth required, we muſt conſider the nature of theſe three given parts, as, whether they be angles or ſides; but we find in this caſe, that the Hypothenuſal is a double term, for it repreſents a ſide; as being a line conſiſting of ſome number of known parts, as Miles, Yards, Feet, Inches, *&c.* and it alſo repreſents an angle, as being the Radius of a Circle, and ſubtending the right angle at B, and ſo muſt contain ſome number of known parts, conſiſting of 1 and Cyphers, and the third term is an angle. Seeing then we have two terms of one kind, *viz.* both angular, we muſt begin with that angular term which relates to the ſide given, and then the Proportion will be as Radius AC is to the Hypothenuſal AC. So is BC the ſine of the angle at A, to the Perpendicular BC.

Again, ſuppoſe the ſame parts to be given and required as afore, and that the Baſe AB in Fig. 12, be made the Radius of a Circle, then from Def. 1. it is evident that BC is the Tangent of the angle at A, and AC the Secant of the ſame angle; therefore the angle at A is a double term, having relation both to the ſide given AC, and to the ſide required BC, and muſt thus be uſed, *viz.* As Secant of the angle A, *viz.* AC, is to Hypothenuſal AC, ſo is Tangent of the angle A, *viz.* BC to the Perpendicular BC.

Laſtly,

Lastly, If the same parts be given and required, (only instead of the angle at A, you use its Complement to a Quadrant, *viz.* the angle C) then CA will be the Secant of the angle at C, and CB the Radius of a Circle, therefore the proportion will be, as CA the Secant of the angle at C, is in proportion to CA the Hypothenusal, so is CB the Radius of the Circle to CB the Perpendicular required.

And by reducing your terms into this order, so that the first and third may be of one kind, you may easily discover the true Canon for resolving any right-angled plain Triangle, as shall more largely appear in the following Cases. And from this Ground may be drawn 24 several varieties or proportions, by making each side of the right-angled Triangle the Radius of a Circle.

ANNOTATION.

1. If the Perpendicular be made Radius, and there be given the Base and Hypothenusal to find the angle at C, we have only two parts given, from whence no Canon can be drawn, because, as I noted before, three parts must always be given.

2. The same thing will happen if the Perpend. and Hypothenusal be given to find the angle at A, when the Base is made the Radius of a Circle.

3. The same is to be understood when we have the Base and Perpendicular given to find the angle at A or C, making the Hypothenusal Radius.

All

All right-angled plain Triangles are usually ranged under seven Cases: whereof those in which a side is required, *viz.* three, may be found by a Triple Proportion, according as each side is made the Radius of a Circle: and those in which an angle is required, may be found by a Double Proportion.

AXIOM 2. Fig. 17.

In all Plain Triangles the sides are proportional to the Sines of their opposite Angles.

Demonst. ABout the Triangle ABC describe a Circle, as BDAFCH from the Center O, then draw the prickt lines AO, BO, CO: it is evident from Def. 4. that the side AB is the Chord of the arch BDA: AC is the Chord of the arch AFC, and BC is the Chord of the arch CHB. From 20, 3. *Euc.* it is evident that the angle BOC is double to the angle BAC, then if you bisect the arch BHC, by the line OH, this line shall bisect BC in I, and the arch BH shall be equal to the angle BAC, but BI by Def. 5. is the Sine of the arch BH, and consequently the Sine of the angle BAC, therefore the Sine of the angle at A, is equal to ½ the subtending side BC.

In like manner it may be demonstrated, that ½ the side AB is equal to the Sine of the angle at C, and that ½ the side AC is equal to the Sine of the angle at B: hence it follows, that what proportion the ½ of any magnitude bears to that whole magnitude, the same proportion doth the ½ of any other

other magnitude bear to that whole magnitude. Therefore

As the ſine of the angle at A (which is ½ the ſide BC) is in proportion to the ſide BC:

So is the ſine of the angle at B (which is ½ the ſide AC) to the ſubtending ſide AC.

AXIOM 3. Fig. 18.

In all plain Triangles, as the Sum of the two ſides containing the Angle given, is in proportion to their difference: So is the Tangent of the ½ Sum of the two unknown Angles, to the Tangent of ½ their difference.

Continue AB to D, and make B D equal to BC, and BF equal to AB, then draw BE, FG each parallel to AC, ſo ſhall the angle DBE be equal to the angle BAC, and the angle EBC ſhall be equal to the angle ACB, becauſe of the parallels BE, AC: and thus the angle DBC, is equal to the Sum of the two unknown angles ABC, ACB. But the Triangle DBC is Iſoſceles: if therefore from B you draw BI perpendicular to DC, it will biſect not only the angle DBC, but the ſide DC in I: therefore the angle DBI, or IBC ſhall be equal to half the Sum of the two unknown angles, *viz.* BAC, ACB, and becauſe EBC is equal to ACB, therefore the angle EBI ſhall be equal to half the difference of the two unknown angles: then becauſe the Triangles DAC, DFG are like by reaſon of the parallels AC, FG, therefore by 4. 6. *Euc.* their ſides ſhall be proportional. But AD is equal to the ſum of the two ſides

A B,

AB, and BC, and DF is the diff. of theſe two ſides, therefore, as the ſum of the two ſides DA. is to their difference DF.

So is the line DC, to the line DG, but if you make BI Radius, and IH equal to IE, then DC is the Tangent of the two unknown angles, and DG the Tangent of their difference equal to H E.

Again, if you draw FM parallel to IA, the Triangles DFM, DAI ſhall be like, and by 4. 6. *Euc.* their ſides ſhall be proportional. Then it is evident that DI (being ½ of DC) is the Tangent of ½ the Sum of the two unknown angles, and DM is equal to HI the Tangent of ½ their difference, therefore, as DA is to DF, ſo is DI to DM, that is,

As the ſum of the two given ſides, *viz.* DA.

Is in proportion to their difference DF.

So is the Tangent of the ½ Sum of the two unknown angles, *viz.* DI.

To the Tangent of half their difference DM, equal to HI, or IE. Then if you add the Tangent IE to the Tangent DI, it makes DE the Tangent of the angle DBE, equal to the angle BAC, and if you ſubtract the Tangent IE from the Tangent IC, it leaves EC the Tangent of the angle EBC, equal to the angle ACB.

AXIOM

AXIOM 4. Fig. 19.

In all Plain Triangles where there are given all the three Angles to find the three sides. As the true Base of the given Triangle is to the Sum of the other two sides. So is the difference of these two sides, to the alternate Base.

LET DBC be a Triangle given, whose three sides are supposed to be known, and let DB the shortest side be the Radius of a Circle, whose Circumference shall cut the line DC in F: continue the line CB to the circumference at A, and draw the lines AF and DH, and the perpend. BG, then shall AC be the Sum of the two sides BC, and BD, and CH shall be the difference of these two sides; Lastly, CF shall be the alternate Base. I say,

The Triangles CHD, CFA are equiangled, because of the angle C, which is common to both the Triangles; and therefore the sides of these two Triangles shall be proportional; therefore it follows, by Cor. 2. 36. 3. *Eucl.* that the Rectangle of CA, CH shall be equal to the Rectangle of CD, CF. But equal Rectangles have their sides proportional by 16. 6. Therefore as the true Base CD.

Is to CA the sum of the other two sides AB, BC. So is the difference of these two sides CH, to the alternate Base CF. Subtract CF from CD, the remainer is DF; from B let fall the Perpend. BG, which shall bisect DF in G, so have you

you resolved the oblique Triangle BCD into two right-angled Triangles BDG, BCG, in either of which we have the Hypothenusals and Bases given to find the angles.

I might have demonstrated these Axioms according to the methods used by the late Reverend Dr. *Oughtred*, and Dr. *Ward*, the latter of which has comprized them in a very few words; but because I have calculated this piece according to the Capacity of our ordinary Seamen, who are not generally qualifi'd to receive speculations so nice, I chose this present method of Expression to render the fundamentals of Trigonometry more perspicuous and intelligible.

CASE 1 Fig. 20.

The base and angle at the base given to find the Perpendicular.

In the right-angled plain Triangle ABC, let the base AB be 94 parts, and the angle at A 38°. 00′ *I demand the Perpendicular BC.*

GEOMETRICALLY.

Draw the line AB, upon which set the base 94 (taken from the line of equal parts) from A to B, and upon B erect the Perpend. BC.

From A with the Chord of 60°. 00′ strike the arch DE, and set the angle given, *viz.* 38°.. 00′ from D to E, draw the line AE, which continue to cut the Perpend. BC in C, so shall BC be the side required, which measured upon the same line of equal parts, gives 74 parts

LOG A-

LOGARITMICALLY.

Making AC Radius, then by Axiom 1. say.
As sine of the angle at C 52°. 00′. —— 98965
Is to the base AB 94 parts —— —— 19731
So is sine of the angle at A 38°. 00′. —— 97893

117624

To the side BC 74 parts —— —— 18659

Making AB Radius.

As the Radius sine of 90°. 00′ —— —— 100000
Is to the base AB 94 parts —— —— 19731
So is tangent of the angle A 38°. 00′ —— 98928

To the Perpendic. or side BC 74 —— —— 18659

Making BC Radius.

As the tangent of the angle C 52°. 00′ —— 101071
Is to the base AB 94 parts —— —— 19731
So is Radius sine of 90°. 00′ —— —— 100000

To the Perpendic. BC 74 parts —— —— 18659

CASE 2. Fig. 20.

The base and angles given to find the Hypotheneusal.

In the right-angled plain Triangles ABC, let the Base AB be 94 parts, and the angle at A 38° 00'. *I demand the Hypothenusal* AC.

The Geometrical Protraction of this Triangle is the same, as in Case 1.

LOGARITHMICALLY.

Making AC Radius.

As Sine of the angle C 52°. 00'. ——	989653
Is to the Base AB 94 parts – ——	197312
So is Radius Sine of 90°. 00' —— —	1000000
To the Hypothenusal AC 119. 3 parts	207659

Making AB Radius.

As the Radius Sine of 90°. 00'. —	1000000
Is to the Base AB 94 parts—— ——	197312
So is the Secant of the angle A 38°. 00'.	1010346
To the Hypothenusal AC 119. 3 ——	207658

Making BC Radius.

As the Tangent of the angle C 52. 00.	1010719
Is to the Base AB 94 parts – ——	197312
So is the Secant of the angle C 52. 00.- -	1021065
	1218377
To the Hypothenusal AC 119. 3 ——	207658

CASE 3. Fig. 20.

The angles and Hypothenusal given to find the Base.

In the Triangle ABC let the angle at A be 38°. 00′ and the Hypothenusal AC 119. 3 parts. *I demand the Base* AB.

GEOMETRICALLY.

Draw the line AB, and from A with the Chord of 60°. 60′. strike the arch DE, from the same line of Chords, take the angle at A 38°. 00′. which set from D to E, and draw the AE at length: also from the line of equal parts take 119. 3 parts, which apply from A to C, bisect AC in F: from F with the distance FA cross the infinite line AB in B. Lastly draw BC, so shall AB be the Base required, which measured upon the same line of equal parts will be 94 for the length thereof required.

LOGARITHMICALLY.

Making AC Radius.

As the Radius AC, Sine 90°. 00′.——	1000000
Is to the Hypothenusal AC 119. 3——	207658
So is the Sine of the angle C 52. 00.—	989653
	———
To the Base AB 94 parts—— —— —	197311

Mak-

Making AB Radius.

As Secant angle A 38°. 00′. ——	—1010346
Is to the Hypothenusal AC 119. 3 parts	2:7658
So is Radius AB, Sine 90°. 00′. ——	1000000
To the Base AB 94 parts ——	——197312

Making BC Radius.

As Secant of the angle C 52°. 00′	—1021065
Is to the Hypothenusal AC 119. 3 parts	207658
So is the Tangent of the angle C 52°. 00′.	1010719
	1218377
To the Base AB 94 parts.——	——197312

CASE 4. Fig. 20

The Base and Perpendicular given to find an Angle,

In the Triangle ABC, let the Base AB be 94 parts, the Perpendicular BC 74 parts. *I demand the acute Angles* A and C.

GEOMETRICALLY.

Draw the line AB, and from the line of equal parts take 94, which set from A to B: upon B erect the Perpendicular BC, and from the same line take 74, which apply from B to C, draw

AC, and from A with the Chord of 60°. 00′ strike the Arch DE, which being applyed to the same line of Chords, will give 38°. 00′. for the measure of the angle at A. Lastly, from C with the Chord of 60°. strike the Arch FG, which applied to the same line will give 52°. 00′. for the measure of the angle C.

In the 3 Annotation of Axiom 1. it is evident that the Hypothenusal cannot be made Radius.

Making the Base Radius.

As the Base AB 94 parts	——	197312
Is to Radius AB Sine of 90°. 00′	——	1000000
So is the Perpendicular BC 74 parts	——	186593
To Tangent of the angle at A 38°. 00′		989281

Making the Perpendicular Radius.

As the Perpendicular BC 74 parts	—	186593
Is to Radius BC Sine of 90°. 00′.	——	1000000
So is the Base AB 94 parts	——	197312
To Tangent of the angle at C 52°. 00′.	—	1010719

CASE 5. Fig. 20.

The Base and Hypothenusal given to find the Angles.

In the Triangle ABC, let the Base AB be 94 parts, the Hypothenusal AC 119. $\frac{1}{10}$ parts. *I demand the Angles* A and C.

GEO-

GEOMETRICALLY.

Draw AB, and from the line of equal parts take 94, which set from A to B, upon B erect the Perpend. BC. and from the same equal parts take 119. 3. with which set one foot in A and with the other cross the Perpendicular BC in C. Lastly, draw the line AC, and from A and C describe the Chord of 60°. 00′. which shall give the measure of the quantity of the angles A and C as in Case 4.

LOGARITHMICALLY.

Making A C Radius.

As the Hypothenusal AC 119. 3 parts	207658
to Radius AC Sine of 90°. 00′.	1000000
is the Base AB 94 parts	197312
to the Sine of the angle at C 52°. 00′.	989654

Making A B Radius.

As the Base AB 94 parts	197312
to Radius AB Sine of 90°. 00′.	1000000
is the Hypothenusal AC 119. 3	207658
Secant of the angle at A 38°. 00′.	1010346

By Annotat. 1. Axiom. 1. the Perpendicular cannot be made Radius, if the angle at C be immediately required.

CASE 6. Fig. 20.

The Base and Perpendicular given to find the Hypothenusal.

In the Triangle ABC, let the Base AB be 94, the Perpendicular AB 74. *I demand the Hypothenusal* AC.

GEOMETRICALLY.

Draw AB and BC at right-angles to each other, and from the line of equal parts take the Base 94, which set from B to A, and the Perpendicular 74, from B to C, draw the line A C, which measured upon the same line of equal parts will give 119. 3 for the length of the Hypothenusal required.

LOGARITHMICALLY.

By Case 4, find either of the acute angles, as the angle at A.

Making the base Radius.

As the base AB 94 parts ——— 1973[illegible]
Is to Radius AB Sine of 90°. 00′. ——— 100000[illegible]
So is the Perpend. BC 74 parts ——— 1869[illegible]

To Tangent of the angle A 38°. 00′. ——— 989[illegible]

Making

Making the Hypoth. Radius.

As Sine of the angle A 38°. 00'.	978934
Is to the Perpend. BC 74 parts	186593
So is Radius AC Sine 90°. 00'.	1000000
To the Hypothenusal AC 119. 3 parts	207659

CASE 7. Fig. 20.

The Base and Hypothenusal given to find the Perpendicular.

In the Right angled Plain Triangle ABC let the base AB be 94 parts, and the Hypothenusal AC 119. 3 parts. I demand the perpend. BC.

GEOMETRICALLY.

This Triangle is to be laid down or protracted as in Case 5.

LOGARITHMICALLY.

To resolve this Triangle by the Canon, there is required a double proportion, for first, by Case 5. you must find one of the acute angles, and then by Case 1*st*. the Perpendicular: but the same may more readily be thus effected.

Add the Base and Hypothenusal together, and find the Logarithme of their Sum; also Subtract the Base from the Hypothenusal, and find the Logarithm

garithm of their difference or remainer, add these two Logarithms together, ½ the Sum thereof shall be the Logarithm of the Perpendic.

AC	119. 3	Logarith. 213. 3.	—	2328[illegible]
AB	94. 0	Logarith. 25.3.	--	140312[illegible]
Sum	213. 3	Sum of the Logarith,		37319[illegible]
Differ.	25. 3	½ Sum 74 Perp.—	—	186595[illegible]

Or in natural numbers by 47. 1. *Eucl.*

From the Square of the Hypoth. — 14232. 49
Subtract the Square of the Base —— 8836.

Then out of the remainer. —— 5396. 49
extract the square root, which is 74 almost for the length of the Perpendicular.

If the Base and Perpendicular be given to find the Hypothenusal, then by 47. 1. To the square of the Base, add the square of the Perpendicular, and the square root of that Sum shall be the length of the Hypothenusal.

Oblique Triangles.

CASE 1*st*. Fig. 21.

Two Sides with an Angle opposite to one of them, to find the other Angles and the third Side.

In the Oblique-angled Plain Triangle ABC let the Angle at A be 34°. 00′, the Side AB 76. and the Side BC 89, I demand the angles at B and C and the Side AC.

GEO-

GEOMETRICALLY.

Draw the line AC. from A with the Chord of 60°. 00. strike the arch DE. and from the same Chords take the angle at A. which apply from D to E. draw the line AE. then from the Equal parts take 76 which apply from A to B. also from the same line take 89. with which distance set one foot in B. and cross the line AC in C. lastly draw the line BC. and upon the angular points B and C describe two arches taking their Radii from the Chord of 60°. so shall FG 28°. 31′ be the measure of the angle C. and HI 117°. 29′ the measure of the angle B. and AC measured upon the line of Equal parts will be 141. for the length thereof.

LOGARITHMICALLY, by Axiom 2.

As the Side BC 89 parts	194939
Is to the Sine of the angle A 34°. 00′	974750
So is the Side AB 76 parts	188081
	1162831
to the Sine of the angle at C 28°. 31′	967892

Then by Theor. 3. add the angles A and C together, their Sum will be 62°. 31′ which Sum subtracted from 180°. the remainer 117°: 29′ is the angle at B.

To

To find the Side AC.

to the line of Equal parts will give 89 for the

To find the Side AC.

As Sine of the angle at A 34°. 00′ —— 974755
Is to the opposite Side BC 89 parts —— 194939
So is Sine angle B 117°. 29′, or 62°. 31′ 994799

118973

to the Side AC 141 parts —— 214981

CASE 2. Fig. 22.

Two Sides with their contained Angle given to find the other Angles and third Side.

In the Oblique Triangle ABC let the Side AC be 141 parts, and the Angle A 34°. 00′. and the Side AB 76 parts. I demand the Angles B. C. and the Side BC.

GEOMETRICALLY.

Draw the line AC from A with the Chord of 60°. 00′ strike the Arch HI, upon which set 34°. 00′ from H to I: draw the line AIB: and from the line of equal parts take 76 which set from A to B and 141 of the same, from A to C then draw BC. and with the Chord of 60°. from B and C strike the Arches KL. MN. which being measured upon the same line of Chords will give the Quantity of the two required Angles. *viz.* C. 28°. 35′. and B 117°. 25′. also BC applyed

to the line of Equal parts will give 89 for the ngth thereof.

LOGARITHMICALLY by Axiom 3.

Add the two Sides AC 141. and AB 76 together, their Sum is 217: alſo ſubtract AB 76. om AC 141. the difference or remainer is 65. en Subtract the given Angle A 34°. from 180°. by Theor. 3. the remainer is 146°. 00′ hich is called the Sum of the two unknown ngles: and 73°. 00′ is the ½ Sum thereof. Then y,

As the Sum of the two Sides AB.AC.217.233645
s to their difference 65 — — — — — 181291
So is the tang. ½ Sum of the unkno. ang. 73.1051466

1232757

to tang. ½ the diff. of the unkno. Ang. 44° 25′-999112

which ½ difference added to the ½ Sum of the two unknown Angles 73°. 00′. makes 117°. 25′ for the Angle at B. and Subtracted from this ½ Sum, the remainer is the leſſer Angle, or Angle at C. 28°. 35′. then to find the Side BC, ſay,

As the Sine of the Angle at C 28°. 35′ 967982
Is to the oppoſite Side AB 76 parts—188081
So is the Sine of the Angle at A 34.00—974750

1162831

to the Side oppoſite BC 89 — parts — 194849

CASE

CASE 3. Fig. 22

The three Sides given to find the three Angles.

In the Oblique-angled Plain Triangle ABC, let the Base AC be 141. the Side AB 76. and the Side BC 89. I demand the angles A. B. C.

GEOMETRICALLY.

Draw the line AC. and from the line of equal parts take 141 which ſet from A to C: alſo from the ſame line take 76, with which ſetting one foot in A. ſtrike the arch B. and with 89 (taken from the ſame line of equal parts) ſet one foot in C, and croſs the arch B in B. then draw the lines AB. BC. and upon each angular point ſtrike the Arches HI. KL. MN. as in the Figure.

That done continue the Side BC to D. and from B. (with the diſtance BA) ſtrike the arch DAE, to cut AC in F. and DC in E: ſo ſhall CD be equal to the Sum of the two given Sides AB. BC. and CE ſhall be their difference; alſo CF ſhall be the Alternate Baſe: Laſtly from B let fall the Perpend. BG, which ſhall always fall in the middle of AF. then to find the alternate Baſe CF, ſay by Ax. 4.

As the true Baſe AC 141	—— ——	214921
Is to Sum of the 2 ſides AB.BC,*viz*.CD 165.		221748
So is the diff. of theſe two Sides CE 13	—	111394
		333142
to the alternate Baſe CF 15. 2	——	118221

Sub-

Subtract CF 15. 2 from AC 141. the remainer ll be AF 125. 8. but AG is the half of AF or . 9. therefore if to GF (equal to AF) 62. 9, u add CF 15. 2. the Sum will be 78. 1 equal GC. And thus the Oblique Triangle ABC is duced into two right-angled Triangles, *viz.* GB. CGB in either of which we have the se and Hypothenusal given, to find the angles, ich may be done by Case 5. making AC Radius

As the Hypoth. AB 76 ——————————188081
to Radius AB. Sine of 90 — 00 — ——1000000
is the Base AB 62-9 parts—— —— —179865

Sine of the angle ABG 55°. 51'. ——991784

ich subtracted from 90°.00'. by Theor. 3. leaves °. 09' for the angle at A. Again
As the Hypothenusal CB 89 ————194849
to Radius Sine of 90°. 00'————10000.0
is the Base CG 78. 1 ——— —————189265

Sine of the angle CBG 61°. 34' ———994416

ich subtracted from 90°. leaves the angle G 28°. 26'.

And for the clearer underſtanding of theſe eral Proportions, grounded upon the preced- Axioms, I have here added a Synopſis of all common Proportions both for right angled l oblique-angled Triangles.

Where note, that S. ſignifies Sine of any an-, t. the Tangent of any angle. Sec. the Secant any angle. R. Radius.

: : propor-

: : proportional. + more, or to be adde
A. the angle A. — less, or to be subtract
B. the angle B.
A. C. the angles A and C. *&c.*
AB. AC. BC. or any two letters not having
point between them, signifies the Side AB.
Side A*&c.* Z the Sum, X the difference.

The Proportions for all Right-angled Plain Triangles.

Given	Requ.	Proportions. Fig. 22.
AC. R. AC. AB.	AC. BC.	S, C. AB:: R. AC. S, C. AB:: S. A. BC.
AC. R. A. AB.	AC. BC.	R. AB:: Sec. A. AC. R. AB:: t, A. BC.
BC. R. C. AB.	AC BC	t, C. AB:: Sec, C. AC. t, C. AB:: R. BC.
AC. R. A.C. AC.	AB CB	R. AC:: S, C. AB. R. AC:: S, A. BC.
AB. R. A. AC.	AB CB	Sec, A. AC:: R. AB. Sec, A. AC:: t, A. BC.
BC. R. C. CA.	AB CB	Sec, C. AC:: t, C. AB. Sec, C. AC:: R. BC.
AC. R. A.C. BC.	AC AB	S, A. BC:: R. AC. S, A. BC:: S, C. AB.
AB. R. A. BC.	AC AB	t, A. BC:: Sec. A. AC. t, A. BC:: R. AB.
BC. R. C. BC.	AC AB	R. BC:: Sec. C. AC. R. BC:: t, C. AB.
AC. R. A .. AB.	C	AC. R:: AB. S, C
AB. R. AC. AB.	A	AB. R:: AC. Sec. A.
AC. R. AC. BC.	A	AC. R:: BC. S, A.
BC. R. AC. BC.	C	BC. R:: AC. Sec, C.
AB. R. AB. BC.	A	AB. R:: BC. t, A.
BC. R. CB. BA.	C	CB. R:: AB. t, C.

THE

The Proportions for all oblique Plain Triangles, a[re] these following. Fig. 23.

	Given	Requ	Proportions. Axiom 2.
1	A B. A. B C.	B C. A C.	B C. S, A :: A B. S, C. the ∠ A C[B] Subtracted from 180°. X is B. A C. S, A. BC :: S. B. A C.
2	A B. C. B C.	A. B. AC.	A B. S, C :: B C. S, A. the ∠ A C[B] Subtracted from 180°. X is B. S. C. A B :: S. B. A C.
3	A C. B. B C.	A. C. A B.	A C. S, B :: B C. S, A. the ∠ B[A] Subtracted from 180° X is C. S, B. A C :: S. C. A B.
4	A. B. C. A B.	B C. A C.	S, C. A B :: S, A. B C. S. C. A B :: S, B. A C.
5	A. B C. B C.	A B. A C.	S, A. B C :: S, C. A B. S, A. B C :: S. B. A C.
6	A. B. C. A C.	B C. A B.	S, B. A C :: S, A. B C. S, B. A C :: S, C. A B.

Axiom 3. Fig. 23.

	Given	Requ	Proportions
1	A B. A. A C.	C B. B C.	AB + A C. AC − AB :: t, B + C. t, B − S, C. A B :: S, A. B C.
2	C B. C. C A.	A. B A B.	CA + CB. CA − CB :: t, B + A. t, B − S. A. BC :: S C. AB.
3	A B. A. B C.	A. C. A C.	BC + BA. BC − BA :: t, A + C. t, A − S, A. B C :: S. B. A C.

Axiom 4 Fig. 23.

Preparation.		AC. BC + AB :: BC − AB. CG − that is AC. CD :: CE CF. thus CF being fo[und] AG − FC = 2 AG. & AG + FC = CG
AC. AB. BC.	A. B. C.	AB. R :: AG. S, ABG. Compt. BA[G] BC. R :: GC. S, CBG. Compt. BC[G]

I ha[ve]

I have now passed over the Geometrical and Logarithmical Solution of all Plain Triangles, in the several Cases. I shall here give two or three Trigonometrical Problems, with application of some Cases of Trigonometry to the business of Navigation

PROB. I. Fig. 24.

Having one Side of a right-angled Plain, Triangle, and the Sum of the other two sides given, to find the angles and the other two sides.

In the right-angled Plain Triangle ABC. let there be given AB 84 parts, and the sum of AD. and BD 178 parts, I demand them severally, and the angles at A and D.

GEOMETRICALLY.

Draw AB. set 84 equal parts from A to B. draw BC perpend. to AB. and set 178 equal parts from B to C. then draw AC. From A with any distance greater than ½ AC. strike the arch EF. and from C with the same extent cross the arch EF. in E and F. then draw the line EF to cut BC in D. lastly draw the line AD. so shall AD be equal to DC. and AD+BD shall be equal to BC.

LOGARITHMICALLY.

As AB	84. pts.	192428
Is to Radius	90°. 00′	1000000
So is BC	178 pts	225042

F to

to Tangent angle BAC 64. 44 — —— 10326
which by Theorem 3. ſubtracted from 90°.
the remainder will be BCA 25°. 16′. But
the Triangle AD.C, the Sides AD. DC are
qual, therefore the angles DAC. DCA are eq
Subtract DAC from B AC ,the remainer wil
BAD 19°. 28′. which ſubtracted from 90°.
remainer will be 50°. 32′ from the angle AD

As Sine of the angle ADB 50°. 32′ — 988
Is to the Side AB 84 parts — ———— 1924
So is the Radius——— 90°.00′——— 10000

to the Side AD 108. 8 parts —— —— —203

which ſubtracted from 178 leaves 69. 2 par
for the Side BD required —

The application whereof may be this, ſuppo
AB to being a broad Ditch,or River, 84 foot,
that BC being the height of a Tree ſtanding up
the Bank thereof be 178 foot. I demand whe
this Tree muſt be cut, ſo that the part cut off m
reach from the top of the ſtanding part to t
further ſide of the River ? Anſwer it muſt be c
at D 69. $\frac{2}{10}$ foot from the Root.

PROB. 2. Fig. 25.

One Side of an Oblique Triangle, the angle oppoſite that Side, and the ſum of the other two Sides being given to find the two Sides ſeverally, and the angl oppoſite Angles to them.

LET the Side AB be 134 parts, and the an
gle at C 112°. and the ſum of the oth
th

wo Sides, AC. ACB 156 parts, I demand them verally, and the angles CAB, CBA.

Draw the line AD upon which set 156 equal rts from A to D: upon D make an angle equal to ½ the angle C viz. to 56°. 00'. and draw D. then with 134 set one foot A, and with e other cross DB in B. lastly draw the angle BD equal to the angle CDB, so shall AC be one the Sides, and CB the other Side required.

LOGARITHMICALLY.

In the Triangle ADB, we have given AD 6. AB 134. and the angle ADB 56°. 00'. to d the angle ABD.

As the Side AB 134	—	212710
to Sine angle ADB 56 – 00	—	991857
is the Side AD 156	—	219312
		1211169
Sine angle ABD. 74° 49'	—	998459

om which subtract the angle CBD 56. 00' the mainer is 18°. 49 viz. the angle ABC.

As Sine angle ACB 112°. 00'	—	996716
to Side AB 134	—	212710
is Sine angle ABC 18°. 49'	—	950858
		1163568
the opposite Side AC. 46.6	—	166852

hich subtracted from AD. the remainer is CD 9. 4. equal to CB.

PROB. 3. Fig. 26.

To find the Diameter of the visible Horizon, that is how far a man can see, by looking round about ... ther upon the Surface of the Earth or Sea.

FOR the Solution of this Prob. you must know that the Diameter of the Earth in English feet is 42078016, and consequently the Semidiameter thereof is 21039008 English feet; then let the Circle DBEF represent the ambit of the Terraqueous Globe, so shall BF be the Diameter, and BC = CD the Semidiameter thereof; then supposing the Eye of the Spectator, *viz.* ... be six foot above the Plain of the Horizon, ... shall CA be 21039014 English feet: I say, ... from A be drawn a line touching the Circumference of this Circle, as AD, it will limit the sight; for nothing can be seen from the point ... below the point D. then draw CD. which by 18. 3. *Euclid*, will be perpendicular to AD, therefore the Triangle ADC is right-angled at D. But in this Triangle we have given CA the Hypothenusal, and CD the Base to find the Perpendicular DA, which by 47. 1. *Euclid* may be thus effected, *viz.*

From the Square of AC, subtract the Square of DC, the Square root extracted out of the remainer is the length of the Perpendicular. As

Thus AC 21039014, multiplyed by it self, produceth 442640110092196 and DC, 21039008 multiplyed by it self produceth 44263985762406 ... subtract the lesser of these two numbers from ...

be greater, the remainder will be 252468132; whose square root 15889 feet, is the length of the Perpendicular AD, and so many feet can the Eye see, when it is elevated 6 foot above the Plain of the Horizon, or convex Superficies of the Earth or Sea, and which reduced into miles, make 3 miles 49 feet.

Another Solution of this Prob. we may deduce from 36. 3. *Euclid*, for the Rectangle made of AF, and AB is equal to the Square of AD.

In Numbers thus, AF 42078022 multiplyed by AB 6 foot, produceth 252468132 Square feet, whose square root 15889 gives the number of feet in AD.

If it be objected that the visual Ray AD is greater than the arch DB, I answer, that seeing the Hypothenusal AC, and the Base CD of this Triangle differ but six foot, therefore the Perpendicular AD and the Arch BD cannot exceed each other six foot, which is but the 2648 part, and therefore inconsiderable.

PROB. 4. Fig. 25.

To find how far the Vertex of any Mountain, Steeple or Ship's Mast may be seen.

In the Solution of this Problem, we must have three things given, *viz.* the heighth of the Eye above the Horizon, AB which suppose to be 6 foot. Secondly the height of the Mountain, Steeple or Ship's Mast DE, which suppose to be 80 foot. Thirdly, The Semidiameter of the Earth GC, which, in the foregoing Problem, was 21039008

English feet: then from the Figure it is evide[nt] that a Right line drawn from E to A mu[st] touch the Surface of the Earth or Sea in F. a[nd] if the Eye be placed at A. the point or object [D] being in a direct line with the tangent AF may b[e] seen from A. then if to the point of Contact [F] be drawn the line CF it shall by 18. 3. *Euclid* b[e] Perpendicular to AE: then by this Proble[m] there is required the Quantity of the Arch BFD which at two Operations may be thus foun[d]. To GD the Diameter of the Earth 4207801[6] add DE 80, the Sum is 42078096, which mult[i]plyed by DE 80 produceth 3366247680; who[se] Square Root 58019 is the number of English fe[et] equal to EF.

Again to BH=DG 42078016 add BA, 6 foo[t] the sum is 42078022. this multiplyed by BA 6 foot, produceth 252468132, whose squa[re] Root 15889 gives the number of Feet in th[e] line AF. But AF 15889, added to EF 58019 th[e] Sum 73908 feet is the length of AE. this divide[d] by 5280 the feet in an English mile gives 13.99 miles from the distance in which the Object D may be seen.

And here also the difference between the Righ[t] line AE and the Arch BFD is inconsiderable.

COROLLARY 1.

Hence it is evident that if the heighth of a Ship's Deck from the Surface of the Water, and th[e] heighth of a Man's Eye from the Deck be give[n] the distance of any other Ship at Sea, just begin[-]ning to appear, may be found.

CO-

COROLLARY 2.

Also if the distance of the top of any Mountain and the point of Contact be given, the height of that Mountain may be found by 47. 1. *Euclid.*

Divers other Conclusions of this nature fall under this head which I must omit at this time, lest what I design for a Manual, insensibly grow greater than I intended.

The explication of the Table of Proportions for Plain Triangles. In number 1. Axiom 1. AC. R. signifies the Side AC is the Radius of the Circle. AC. AB signifies the angle A. angle C. and Side AB are given.

S, C. AB : : R. AC is thus to be read. As Sine of the angle C is in proportion to the Side AB. So is the Radius AC to the Hypothenusal BC. And thus you may understand how to read the Proportions in the 1*st*. and 2*d*. Axioms.

In AXIOM 3.

In number 1. we have given the side AB. the side AC. and the angle A to find the angle C and B. and the side BC. the Proportion is thus exprest. As AB+AC. AC+AB : : tB+C. tB−C. that is as AC added to AB. is to AB subtracted from AC. (that is the difference between AB. and AC.) so is the sum of the angles B and C. to the difference of the angles B and C. the rest need no explaining.

The Art of Navigation,

DEMONSTRATED

FROM THE

PRINCIPLES

OF

GEOGRAPHY

CHAP. 7.

Of the Position of Places.

GEography is a mixt Mathematical Science teaching us the true Notion of the Earth in relation to its Figure, Place, Magnitude, and other Properties.

It is divided into two Parts, *viz.* universal and particular. The Universal, teacheth us to consid-

consider the Earth in general, and to explain all the affections and proprieties thereof, without taking notice of particular Countries. The particular considereth the constitution of all the several Countaies of the Earth.

This Art or Science of Geography is no new thing, nor was it (as *Lucius* says of the Roman People,) *unius ætatis*, the Production of one age, but of many; For the antient Geographers were continually at work upon the Chorography of Kingdoms or Countries, and the Topography of particular places. Thus we find the Conquering Romans, who when they had subdued any Province, commanded the Survey thereof to be taken, and upon their Triumphs to be exposed to the Eyes of the Spectators. And we see, that War which is commonly the ruine of most other Arts and Sciences, has alwayes continued a Friend to Geography; witness *Alexander*'s *Asiatick* Expedition, as *Pliny* tells us, at which time he took along with him two Surveyers or Measurers, *Diogetus* and *Beto*, to whose performances the Geographers in succeeding Ages, were much indebted. Yet notwithstanding all this diligence used by the Antients, the Maps which they produced and left to posterity were very imperfect and false; because they were altogether ignorant of several Parts of the Earth, which in after times (upon the discovery of the Magnet) were found out: for it was impossible till that happy discovery was made) to Sail round the Globe. I mean not that they were ignorant of the secret property of the Magnets attracting of Iron, for this they understood; but that it was capable of a

Peculiar

peculiar directions to a Meridional Position, was a secret they never imagined: And even this useful Arcanum had remained perhaps for ever undiscovered, if (like the invention of Gun-powder) some particular accident had not lead us to the Consideration of it; as you may see more at large in *Kercher* [illegible] *Magnete.*

Nor would this secret Property of the Stone have been of use further than in private Speculations, if Navigation had been unknown.

For by this Art, Geography has attained its present improvement; and it is not to be doubted but that by the help of Navigation it will in succeeding Generations be brought to perfection.

In what Age of the World, Men first began to think of Travelling by Sea, is somewhat difficult to determine. We are certain that *Europe* was at first peopled upon all the Sea Coasts from the East, and therefore Navigation was very Ancient. Accordingly *Moses* in describing the first Peopling of the World, calls *Europe* by the name of Isles of the *Gentiles*, implying that the Jews accounted it's several Regions accessible to them only by Water, after the manner of Islands. The several Colonies sent in the first Ages by the *Egyptians Phœnicians* and *Greeks* through the *Mediterranean* are further Testimonies of this thing. Jacob in his blessing of *Zebulon*, mentions Ships upon the *Mediterranean*, as a thing well known in his dayes. The Antient *Phœnicians* Traded as Merchants, and are celebrated in Scripture for it. *Ezek.* 27. and when *Solomon* built a Navy upon the Read Sea, he used [illegible] Pilots.

The Ship *Argos* built only to Sayl through the *Euxim* Sea to *Colchos* was the first of Note among the *Greeks*, and therefore was by the *Antients* placed in Heaven among the Constellations in Memory thereof. *Minos* King of *Crete* is reputed the first who built a Navy of Ships for War, and Ruled over the Seas. And in his dayes *Dedalus* with his Son *Icarus* were the first who applied Masts and Sayls to Ships. For till then they Sayled only by Oars, Others invented Rudders, Anchors, the Compass and other things, by which Shipping has been gradually brought to the perfection in which we find it at present.

As

As the Science of Geometry was occasionally discovered by the frequent Inundations of the River *Nilus*: and that of Astronomy by the *Chaldean Shepherds*; and as these two admired Arts in their first appearance to Man were rude and impolished. For Geometry was only imployed in finding out each man's *Quantum* of Ground, when the overflowings of *Nile* had defaced the stated Land-marks. And Astronomy was no further regarded than in noting the several magnitudes of the Stars, and reducing some few of them into Constellations. So this Art of Sailing (when first it was thought on) was as imperfect as either of the other. The first Vessels being not much unlike those Canoes we find still used by the Indians. But these poor open Vessels were afterwards improved, and in a long tract of time attained to the perfection which we see at present.

Navigation (upon which the perfection of Geography does depend) is an Art or Science which teacheth us how to direct a Ship through the untract Ocean, from any one place to any other assigned.

Without the knowledge of the Position of Places, it is altogether impossible to understand this Art of Direction. And the Position of Places cannot be understood, till it be known what Latitude and Longitude those places lie in.

In the first Chapter I gave you some general Definitions of those two Terms, and here I shall further explain them.

1. The

1. The Circle of Longitude of any Place upon the Surface of the Terraqueous Globe, is the Circle which passeth through that Place, and also through both the Poles of the Earth. This Circle of Longitude is also called the Meridian; for the Meridian of any Place and the Circle of Longitude of the Place are one and the same Circle, distinguished only by their use. For the Meridian respects the motion of the Stars; and the Circle of Longitude respects the Extension of the Earth without any regard to the Celestial Motions. These Meridians, or Circles of Longitude, upon all Globes are usually drawn through every 10th, or 5th degree of the Equator, and upon Maps, they usually pass through every Degree of the same.

2. The Longitude of any Place is the distance of the Meridian of that Place from some other particular Meridian. It is also sometimes called an arch of the Equator or Parallel intercepted between the Meridian of any one Place, and any other certain Meridian. And this Meridian from which the Meridians of all other Places are numbered, *viz.* from West to East is called the first Meridian, and the Longitude of the whole Earth is called its extension from West to East, measured in the Equator. Thus then, the first Meridian (being the *Terminus a quo*, or beginning of Longitude) is said to lye in no Longitude, if any place therefore lye 1, 2, 3, or 50, 70, 140, 320. *&c.* degrees distant from the first Meridian, *viz.* counting from West to East in the Equator, the number of degrees in which

this

this second place lyeth, is called the Longitude thereof.

3. The distance of any one place from another is the shortest line intercepted between these two places, upon the surface of the Earth. Hence then as the Terraqueous Globe is Spherical, all lines drawn upon the Surface thereof must be Spherical, and therefore the distance between any two places must always be an arch of a Circle.

That the true Idea or Notion of Longitude may be more exactly apprehended by one ordinary Seaman, (for whose use alone I undertook the Composure of this piece) I shall cast my thoughts into these following Propositions.

PROP. I.

Nature her self has placed no particular beginning or term of the Earth's extension from West to East, (or according to the Equator,) hence any of the Meridians may be taken for the first Meridian, or beginning of Longitude.

Every Superficies whether Plain or Curved, is determined and measured by two divisions, or extensions; of which extensions, the one is called the length or Longitude of that Figure or Superficies, and the other the breadth or Latitude thereof, and the length and breadth of any Superficies is always conceived to be perpendicular to each other: Nor do these two extensions differ from each other in nature, for that which we assume for the Longitude, may likewise be assumed for the Latitude, and the contrary: but usually

usually when these two extensions are unequal, we assume the longest for the Longitude, and the shortest for the Latitude.

Thus in ordinate Figures, as in the equilateral Triangle, the Square, &c. these two extensions being equal, there is no difference between the Longitude and Latitude of them. In like manner the Figure of the Earth being Spherical, the Dimensions thereof are equal, and so the length and breadth, or Latitude and Longitude thereof must not differ, but onely according to our Conceptions, that these two terms may be more obvious to us. But why the one should be called Longitude rather than the other, we will here enquire.

Seeing that the *Meridians* do all meet in the Poles of the Earth, which are alwayes a Semicircle asunder from each other. This Semicircle we will take for one of the Earth's Dimensions; and seeing the Equator equidistant every where from those two Poles, is continued without interruption, to a whole Circle, we will take this for the other Dimension of this Spherical Surface; but this being a whole Circle is longer than the other being onely a Semicircle, therefore the Equator must be the Measure of the Earth's length or Longitude, and the Meridian, the Measure of its breadth or Latitude. In the Second Chap. I shewed you how to find the Latitude of any Place by an observation of the Sun's or any Star's Meridian Altitude; I will here subjoyn some particular Methods for finding the Longitude of any Place by observation.

PROP.

PROP. 2.

To find the Longitude of any Place by observation.

The Method for finding the Latitude of any Place depends upon the immobility of the Poles of the World, and the process for finding the Longitude of any Place depends upon the inequality of the motion of Celestial Bodies: for if both the Fixed Stars and the Planets be moved with an equal degree of Velocity from East to West, every of these in the same number of Hours shall pass through all the Meridians of the whole Earth. But according to the truth of the matter (by reason of the inequality of the motion of the Celestial Bodies) if any fixed Star comes to any Meridian at 12 H afternoon, it shall come to that Meridian which is 90°. distant to the Westward at 11. H. 59 M. and consequently the Errour of one Minute of time, in the Sun's Motion, produceth an Errour in Longitude of about 90 D.

Also if the Moon (whose motion is the swiftest of all) comes to any Meridian at 12 a Clock, we shall come to a Meridian which lyes 7D. 12′ Westward, about 12 H. 1 M. and therefore from the Errour of one Minute of an hour in the Moon's motion from the Sun, ariseth an Errour of 7°. 12′ in the Longitude of the Place propounded, and in the motion of the same Moon from any one fixed Star riseth an Errour of 6°. 48′. and in the same manner the Errour increaseth in the rest of the Planets, both from the Planets Place

Place taken by obſervation, and from the Ta[illegible] calculated according to the proportion betw[illegible] the motion of the Planet obſerved, and the m[illegible]tion of the *Primum Mobile*.

Then ſeeing the difference of Longitu[illegible] cannot be obtained by help of Celeſtial obſerv[illegible]tions, unleſs the Hours of both Places be ſ[illegible] known whoſe difference of Longitude, is ſoug[illegible] it is evident that if the Errours at both Pla[illegible] be not of the ſame denomination, and leſſer t[illegible] one minute of time, the Errour of Longitud: c[illegible] not be leſs than 13°.

Hence it is manifeſt how difficult (if not i[illegible]poſſible) it is to find the Ship's Longitude at S[illegible] by obſervation of the Celeſtial Bodies, and t[illegible] the whole uſe of ſuch Obſervations is to be re[illegible]red to Geography and Aſtronomy. However ſ[illegible]ing it may be of uſe for our Seamen to know t[illegible] various Methods, I ſhall here inſert them.

METHOD 1.

To find the Longitude of any Place by an Eclipſe [illegible] the Moon.

This way would be of very great uſe if [illegible] could ſee an Eclipſe every night: and may t[illegible] be effected. At that moment of time wh[illegible] through a Teleſcope you obſerve the beginning [illegible] middle of an Eclipſe, You muſt take the Al[illegible]tude of a fixed Star, whether it be upon the M[illegible]ridian or in any Azimuth, it matters not; but [illegible] the Star be in the Meridian, You may (if Y[illegible] knew it not before) find the Latitude of t[illegible]

Plac[illegible]

lace; which Astral Altitude (being taken) nd the hour of the Night with all possible exact-ness; which is most easily done by this following ule, if the Star be upon the Meridian, *viz.* To e Complement of the Sun's Right Ascen. H. M. add the Star's Right Asc. in H. M. the m is the time required. Compare this time of e Night thus found, with the time of the be-inning or Middle of the Eclipse, found by the lmanack or Ephemeris calculated for that E-ipse, and the difference between those two, is e difference in time between the Place for whose eridian the Ephemeris was calculated, and the lace where this observation was made. And e Longitude of the Place where this observa-on was made, may be found by converting the ours and Minutes in the difference in time be-een the two Places, into Degrees and Minutes f the Equator.

METHOD 2.

o find the Longitude of any Place, having the Moon's Place in the Zodiac given.

Altho' the preceding Method by an Eclipse of e Moon be the most accurate, yet because E-ipses seldome happen, and when they do, are ot visible in all Places, therefore the precepts here delivered are not so useful to Seamen at ea; being rather accommodated to the Shore; nd thereby the Longitudes of most Places were iscovered; but to our present purpose.

G Find

Find the true moment of time in which th
Moon comes to the Meridian, and thereby th
Longitude of any Place required may be fo
after this manner.

In the Place of Observation, (the Latitu
being known) find the Altitude of any know
Star, and thereby the hour of the Night wi
all imaginable accuracy: but note that the Al
tude of the Star must be taken precisely wh
the Moon is upon the Meridian. Next, fi
what degree of the Zodiac or Ecliptic is in th
Medium Cœli at that same instant of time
and thus for the time found we have the Moo
true Place in the Zodiac. Then from the Tab
calculated for the Meridian of that Ephemer
find the hour in which the Moon shall be in th
point of the Zodiac: and we shall have the hor
ry difference in time between the two Places, vi
of the Place where the Observation was mad
whose Longitude is unknown, and also of th
Place to whose Meridian the Ephemeris wa
calculated: and then proceed as in the form
Method.

METHOD 3.

To find the Longitude of any Place by the Satelli of Jupiter.

Many there are who prefer this Phænomeno
before others, because the Satellites of *Jupiter* hav
no sensible Parallax, and in every Position of *Jupi*
above the Horizon, are conveniently to be ob
served. About this Glorious Planet *Jupiter* ther
ar

re four Satellites (invisible to most naked Eyes, tho' very easily perceived through a Telescope) which continually move round about *Jupiter*, respecting him as their Common Center. Their proper motion by which they are carried about *Jupiter* (for their diurnal motion, and their motion in the Ecliptic is common to all the fixed Stars, to *Jupiter* and the rest of the Planets) is swift: That which is nearest to *Jupiter* finisheth his circuit in one day, 18 Hours. The Second in 3 Dayes 13 Hours, the Third in 7 Dayes two Hours, and the Fourth in 16 Dayes 18 Hours. If then you would find the Longitude of any Place by the Stated Motions of the Satellites, You must (by a most exact Telescope) observe the conjunction of any two of these Satellites with *Jupiter*, and to that moment of time in which you make this Observation find the true time either by the Meridian Altitude or other Azimuthal Altitude of any known Star: then in Your Tables of the Motions of these Satellites, find the true time, in which the Conjunction (You observe) shall happen; *viz.* at the Meridian of the Place by which the Tables were calculated: and thus You have as afore the difference in Time between the Meridian of the Tables, and the Meridian of the Place of Observation, which being reduced into Equatorial Degrees, gives the difference of Longitude between these two Meridians.

But seeing that these Tables (for want of a sufficient number of Observations) are not arrived to their desired perfection, I shall only give you this following: but dare not recommend it to Your Use for finding the Ship's Longitude at Sea.

A Table of the Eclipses of Jupiter's *Satellites, visible under th ridian of the Observatory, or near it,* Anno 1693.

January

D.	H.	M.	Satel.	
2	8.	27	4	I
2	10.	51	4	E
3	11.	23	2	E
4	9.	40	3	I
4	12.	49	3	E
5	14.	02	1	E
7	8.	32	1	E
10	13.	58	2	E
11	13.	39	3	I
14	10.	24	1	E
16	4.	53	1	E
19	5.	02	4	E
21	5.	21	2	E
21	12.	18	1	E
23	6.	47	1	E
28	8.	28	2	E
28	14.	14	1	E
30	8.	42	1	E

February

D.	H.	M.	Satel.	
2	3.	50	3	I
4	11.	5	2	E
6	10.	38	1	E
8	5.	7	1	E
9	5.	48	3	I
9	8.	53	3	E
11	13.	33	2	E
13	12.	35	1	E
15	7.	04	1	E
16	9.	43	3	I
16	12.	55	3	E
22	5.	41	2	E
22	9.	01	1	E

March

D.	H.	M.	Satel.	
1	8.	21	2	I
1	10.	[illegible]	1	E
[illegible]	11.	0	2	E
10	7.	36	1	E
10	8.	53	4	E
10	11.	54	4	E
17	9.	24	1	E
14	9.	13	3	E
24	12.	22	1	E
31	10.	00	3	I

April

D.	H.	M.	Satel.	
2	7.	48	1	E
2	8.	17	2	E
9	9.	45	1	E
9	10.	56	2	E
25	8.	8	1	E

May

D.	H.	M.	Satel.	
2	10.	3	1	E
4	8.	8	2	E
6	9.	27	3	E
16	9.	24	4	I

☌ ☉ ♃

July

D.	H.	M.	Satel.	
3	15.	15	2	I
5	15.	25	4	I
15	15.	38	1	I
21	12.	57	1	I

August

D.	H.	M.	Satel.	
4	14.	55	2	I
7	15.	51	1	I
14	13.	53	3	I
14	17.	7	1	I
23	14.	11	1	I
30	16.	7	1	I

September

D.	H.	M.	Satel.	
5	14.	41	[illegible]	I
8	12.	32	1	I
10	15.	41	4	I
15	14.	27	1	I
19	13.	26	3	E
22	16.	23	1	I
26	13.	57	4	I
26	17.	27	4	E
27	14.	3	4	E
29	18.	18	1	E
30	11.	50	2	E

October.

D.	H.	M.	Satel.	
1	12.	47	1	I
3	17.	57	3	I
7	14.	26	2	I
8	14.	41	1	I
14	16.	2	2	I
15	16.	35	1	I
22	18.	29	1	I
24	12.	58	1	I
25	9.	24	3	E
31	11.	50	1	I

November

D.	H.	M.	Satel.	
1	9.	52	3	I
1	11.	28	2	I
1	13.	24	3	E
2	9.	19	1	E
7	16.	42	1	I
8	13.	49	3	I
8	4.	1	2	I
8	17.	20	1	E
9	11.	10	1	I
14	18.	34	1	I
15	16.	34	2	I
15	17.	45	3	
16	13.	3	1	
16	15.	46	4	
16	20.	15	4	
18	7.	30	3	
22	19.	6	1	
23	14.	52	1	
25	9.	20	1	
26	8.	22	2	
[illegible]	16.	41	1	

December

D.	H.	M.	Satel.	
2	11.	10	1	
3	9.	39	4	
3	11.	22		
5	14.	12	4	
7	18.	33	1	
9	13.	01	1	
9	13.	26	2	
11	7.	28	1	
14	9.	26	3	
16	14.	50	1	
17	15.	57	2	
18	9.	18	1	
20	8.	8	4	
21	5.	13	2	
21	13.	22	3	
23	16.	42	1	
24	18.	29	2	
25	11.	10	1	
27	5.	39	1	
28	17.	18	3	
30	18.	33	1	

☍ ☉ ♃

The explication and use of the foregoing Table.

First, you must have in readiness a Tube or Telescope 12 or 14 foot long, which directed to *Jupiter* will shew his Satellites; which, otherwise, are inconspicuous to most Men.

Secondly, at the time of observation (which must alwayes be when some or other of these are in Eclipse.) You must find the true time of the Night, either by the Altitude of a Star in any Azimuth; or by any Stars coming upon the Meridian at that time.

Then by comparing the Time between the Meridian for which the foregoing Table was Calculated, and that which You find either by the Culmination of any Star, or it s Altitude upon any other Azimuth, You may attain the difference in time between these two Meridians: which difference reduced into Degrees and Minutes shews the Longitude of the Place required, or the distance of those two Meridians at the Equator.

The Table it self shews You all the Eclipses of the four Satellites for every Month of the Year, and upon what day of the Month, and hour and Minute of the Day each Eclipse happens. The Letter E signifies the Emersion or end of the Eclipse, and I the Immersion or beginning thereof. Thus against *September* 26 You find 13 H. 57 Minutes, and in the responding Satellite

Column You find 4 $\left\{ \frac{I.}{E.} \right.$

the meaning where f is that upon *September* 26 at 13 H. 27 M afternoon, the 4*th*. Satellite immergeth, or entereth the Shadow of *Jupiter*, and at 17 H. 27 M. the same Satellite emergeth again from the Shadow of *Jupiter*, and consequently the Eclipse then endeth.

Also against *December* 2. stands 11 H. 10 against which stands 1 I.which shews that the first Satellite immergeth or beginneth to be Eclipsed that day at 11 H. 10 M afternoon. And upon *December* 30. the Table shews You that the first 1 Satellite emergeth or ceaseth to be Eclipsed at 18 H. 33 M afternoon.

The use of all which is this.

Admit I be at Sea *October* the 8*th*. 1693. and by my Telescope I find the Immersion of the first Satellite at 3 a Clock 48 M. past, in the Morning, *viz*. by an observation taken of some Stars Altitude, but by the Table I find the Immersion to be 14 H. 41 M. therefore

	H M	H
From the observed time	3. 48, adding 12 H	15
Subtract the Tabular time — -	——	14
the remainer is —— —— —	——	1

which may thus be reduced into Degrees and Minutes. You must know that for every Hour of time, 15°. 00′ of the Equator must pass the Meridian ; therefore find the Minutes in the di-

rence in time, which in this Example is 1 H. 07 M. *viz.* 67 minutes. Also find the Equatorial minutes in 15°. 00′. by multiplying 15 by 60, the Product 900, gives the Equatorial minutes required, then say

If 60. 900 :: 67
900

6 | 6030 | 0 | 1005 Minutes.
| 0 |

divide 1005 by 60 (the minutes in a Degree, and the Quotient is 16°. 45′. for the dist. in Longitude between the Meridian of the Ship, and that of the place for whose Meridian the Table was calculated.

But this way, which really is very exact, labours under two inconveniencies scarce to be remedied, *viz.* the almost impossibility of finding true time at Sea, and of managing a Telescope 10 or 12 foot long on board of a Ship.

A *Catalogue of the Eclipses of* Jupiter's *Satellites visible unde Meridian of the Observatory, or near it,* Anno 1694.

January

D.	H.	M.	Satel.	
1	15.	20	1	E
3	9.	48	1	E
4	13.	03	2	E
5	4.	16	1	E
8	17.	12	1	E
10	11.	40	1	E
11	15.	51	2	E
12	6.	08	1	E
15	5.	04	2	E
17	13.	33	1	E
18	18.	21	2	E
19	8.	02	1	E
19	8.	44	3	E
22	15.	18	4	I
22	17.	39	2	E
24	15.	07	1	E
25	8.	56	1	E
26	12.	43	3	E
28	4.	24	1	E
29	10.	15	2	E
31	17.	22	1	E

February

D.	H.	M.	Satel.	
2	11.	50	1	E
4	6	19	1	E
5	12.	51	2	E
8	9.	25	4	I
8	14.	05	4	I
9	13.	46	1	E
9	17.	08	3	I
11	8.	1[illegible]	1	E
12	15.	28	2	E
16	14.	42	1	E
18	10.	12	1	E
19	18.	06	2	E
21	7.	2[illegible]	2	E
24	4.	48	3	E
25	8.	21	4	E
25	12.	09	1	E
27	6.	37	1	E

March

D.	H.	M.	Satel.	
2	10.	14	2	E
3	8.	40	3	E
4	14.	06	1	E
6	8.	35	1	E
9	12.	43	2	E
10	9.	16	3	I
10	12.	52	3	E
11	16.	03	1	E
13	10.	32	1	E
17	13.	18	3	I
17	16.	55	3	E
20	12.	30	1	E
22	7.	00	1	E
27	7.	20	2	E
29	8.	57	1	E
2[illegible]	15.	58	4	I

April

D.	H.	M.	Satel.	
3	9.	50	2	E
5	10.	55	1	E
10	12.	27	2	E
12	12.	52	1	E
14	7.	21	1	E
15	9.	01	3	E
16	10.	06	4	I
21	9.	17	1	E
22	9.	28	3	I
22	13.	05	3	E
28	11.	13	1	E
29	12.	20	2	I

May

D.	H.	M.	Satel.	
5	9.	47	2	E
14	9.	31	1	E
28	9.	4	3	E

June

D.	H.	M.	Satel.	
3	9.	3	4	E
6	9.	41	1	E

July

Conjunction of Sun and Jupiter.

August

D.	H.	M.	Satel.	
3	17.	3	1	I
5	16.	32	2	I
19	15.	23	1	I
28	15.	16	4	E

September

D.	H.	M.	Satel.	
11	15.	39	1	I
12	17.	19	3	I
18	17.	35	1	I
25	13.	59	1	I

October

D.	H.	M.	Satel.	
1	13.	26	2	I
4	15.	54	1	I
8	16.	2	2	I
11	12.	50	3	E
11	17.	40	1	I
15	18.	38	2	I
18	13.	12	3	I
18	16.	49	3	E
25	17.	10	1	I
27	16.	4	1	I

November

D.	H.M.	Sa
3	17.57	1
4	15.16	4
5	12.25	1
12	14.16	1
16	18. 8	2
19	16. 7	1
21	10.34	1
23	12.3[illegible]	3
26	17.47	1
27	9.56	2
28	12.24	1

December

D.	H.M.	Sa
4	12.26	2
5	14.14	1
7	16.42	3
11	14.36	2
12	16. 4	1
14	10.32	1
18	7.28	2
19	17.54	1
21	12.21	1
23	16. 6	4
26	19.43	1
28	14.11	1
29	9.14	2

In this Table of the Eclipses of *Jupiter*'s Satellites calculated for 1694. You are to note that the Eclipses of the first Satellites are the most convenient for determining the difference of Longitudes of distant places; not only because they happen more frequently, and may be distinctly seen with a good Telescope of 8, 10 or 12 foot long, but also because its motion is found more regular.

The Eclipses in this Table, are such as are visible in *England*, but to find when any other Eclipse not visible to us, but under some remote Meridian happens, you must first take the mean Revolutions of the Satellites, which are as follow.

	D	H	M	S
The mean Revol. of the first is made in	1.	18.	28.	36
of the Second in——	3.	13.	17.	54
of the Third in——	7.	03.	59.	36
of the Fourth in –	16.	18.	05.	03

Then to find when the next Eclipse of the first Satellite will happen after *October* 4 1694. you must

To the given time of the Catalogue for *Oct*. 4. *viz*. 15 H. 54 M. add the time of one Revolution, *viz*. 1 D. 18 H. 28 M. 36 S. the Sum is 2 D. 14 H. 22 M. 36 S. which add to *Oct*. 4. makes *Oct*. 6. D. 14 H. 22 M. 36 S. *viz*. the time of the next Immersion: and thus you may proceed for all the rest, and by help of a Terrestrial Globe rectified for the Latitude of *London*, and to the day of the month, you may find where any other Immersion or Emersion will be visible.

M E-

METHOD 4.

The methods hitherto declared for finding the true Longitude of places are not so universally useful as might be hoped, because they (depending upon Celestial Phænomena's) cannot always be put in practice. For not only a Cloudy Sky hinders our purpose, but many times the Eclipses of the Moon (happening in places far distant from us) are not to be observed by us; and sometimes also the Satellites of *Jupiter* (when that Planet is near the Rayes of the Sun, or when he is below the Horizon) are altogether useless for our purpose. These inconveniencies have been endeavoured to be remedied by Automatons or unerring Clocks: but what man will pretend to make a movement which shall always keep the same pace without any difference in motion; nay were it possible to contrive so curious a piece of Clockwork, whose motion should be equal at all times in the place where it was made, yet experience tells us that tho a Clock goes just and regular in one place, yet its motion will vary in another Country. For example: if its motion be certain and regular at *Lond.* it shall be uncertain at *Nova-Zembla*, and the farther you advance within the Artic or Antartic Circles, towards either of the Poles, the motion shall be so much slower than at *London*, nay, the motion thereof shall be retarded, tho you increase the weight: and consequently when these Correct Automatons are carried into an air more warm than that in which they

they were made, their motion shall be swifter than before.

The reason whereof I will not determine, that is, whether these different degrees of motion in Clocks be imputable to the air, or to the figure of the Earth: but proceed to shew how (supposing such Clocks to keep a just and regular motion in all parts of the Earth) the Longitude of places might be discovered by them.

When you depart from any place rectifie your Clock most accurately to that hour and minute of your departure, so shall your Clock shew you the true time for that place from whence you departed; then find the true time at that place to which you are come; (either by the Sun in the day, or by the Stars in the night) and by converting the hours and minutes (between these two times) into Degrees and Minutes, you have the difference of Longitude between the Meridian you first departed from, and the Meridian you are come into.

I have now done with the methods commonly made use of for finding the Longitude of places at Land: I wish any of them could be put in practice at Sea, that so Navigation might attain its desired Perfection; however all my design in handling this matter so largely, is to give the Reader some certain Idea of the business of Longitude, and that there is no such mystery in this Notion, as our ordinary Seamen commonly imagine. And thus by knowing the Latitude and Longitude of any two places, we may readily conceive their position, or place upon the Superficies of the Globe.

CHAP.

CHAP. VIII.

The Description, Delineation and u of all Geographical Maps.

MAPS are the lively representation of t Position of Places. Of Maps, some a Spherical, and consequently universal; othe Rectilinear, and generally particular: we wi first begin with the Circular or Spherical Proj ction of Maps, as being most like to the Form o Figure of the Earth.

It is to be wondered at, that amongst so ma ny as apply themselves to the study of Geogra phy, there are but few to be found who throug ly understand the Construction of Geograph cal Maps: for who can pretend to judge o conveniences or inconveniences of Maps, th are utterly ignorant of the foundations where on they are placed. And seeing the whole skil of the construction of Maps depends upon th Principles of Opticks (commonly called Pe spective) I shall here explain so much thereo as may be sufficient for our present purpose.

This

This Art of Perſpective teacheth us to repreſent all manner of Objects upon a Plain or Table in their true Site or Poſition; according as they appear to the Eye, howſoever it be poſited; which how to perform I ſhall here inſtruct You.

When we deſire to repreſent any Point, Superficies, or any Body in a Table (whether we really ſee them with our naked Eye, or ſuppoſe the Idea thereof in our mind) we ought firſt to ſuppoſe the viſible Object to be ſeen by one Eye, as from a Point: and to aſſign the Place, Site of Poſition of the Eye, from whence the Aſpect proceeds.

Secondly, in beholding any viſible Object, we ſuppoſe an infinite Plain, called the Glaſs or tranſparent medium to be placed between the Eye and the Object.

Thirdly, we ought to conceive, that from every Point of the Object there may be Rayes or Lines drawn (through this *Diaphanous* Medium) to the Eye, which Lines (ſo ſuppoſed) ſhall cut the Medium in certain points, and theſe points duly joyned by lines drawn from point to point, ſhall give the true repreſentation of the Object from that ſame ſight or poſition of the Eye. But this Optick contrivance holds not true in all Caſes, as may be eaſily conceived from the various poſitions of the interpoſed Medium; yet becauſe there is not hitherto a better way invented, we will content our ſelves with this for the preſent.

Thus then ſuppoſe the Earth with all it's Places upon the Periphery or Surface thereof were required

quired to be represented in *Plano*, and that the Eye be posited some where in the Aer

Then between the Eye and the Object, let there be a supposititious transparent Plain; whose position (tho it may be taken at pleasure) to render the appearance of the Object more regular, we will suppose to be at right angles to that fictitious line which is conceived to be drawn from the Eye to the Center of the Earth: and from all the points in the Surface of the Earth, let us suppose lines to be drawn to the Eye; then shall these lines or visual Rayes cut this *Diaphanous* Plain in certain points, and these points duly joyned shall give the Representation of the Places in the Surface of the Earth: *Lastly*, if these Points in the Surface be all taken from any of the Circles of the Sphere, as from points in the Equator, Meridian, Tropics, &c. and be conjoyned by lines drawn from point to point, these connected lines (whether right or curved) shall be the Image, or Representation of the Circle, from whose Periphery they were drawn.

And by this Artifice may all the Circles of the Globe, and all the places in the Surface thereof be exactly represented.

And seeing the Earth is round, therefore the whole Surface of the Earth (with all the Places thereon) cannot be represented upon one Plane, because any two Places Diametrically opposite to each other, must be represented by one and the same point: so that if You desire a true Representation of all Places, You must do the same by two equal Hemispheres.

By

By this ſhort view of Perſpective, I hope the
eader can be able rationally to conceive how all
e Surface of the Terraqueous Globe may be re-
reſented in *Plano*: and that nothing may appear
anting to his further Inſtruction, I ſhall explain
heſe two following Particulars upon which the
veral varieties of Geographical Tables do de-
end.

Firſt, I told You that in drawing the Image or
epreſentation of any Object, there muſt be a
oint aſſigned for the poſition or Place of the
ye, which point ocular muſt alwayes be taken
me where diſtant from the Object: then be-
auſe about any Object there is an infinite ſpace;
nd ſo there may be an infinite number of points
om whence the Eye may view the Hemiſphere of
e Earth; if from ſeveral of theſe infinite points
here be Rayes or lines drawn to ſundry points
the Hemiſphere, (all which are ſuppoſed to
aſs through the *Diaphanous* Medium) there ſhall
riſe ſundry various Repreſentations of this
emiſphere, according to the different Situations
r poſitions of the Eye.

Thus, when the Eye is directly poſited againſt
he middle of any Frontiſpiece of an Houſe, the
iſual Rayes drawn from each point in the Fron-
iſpiece (through the interpoſed *Diaphane*) to
he Eye, make one kind of Image or Repreſen-
ation thereof: and when the Eye is poſited either
igher or lower; Obliquely to the right or
eft hand thereof, the Repreſentation is (at
ach of the Poſitions) different from the former.

And thus it is in the Repreſentation of the
emiſphere of the Earth: for if the Eye be
placed

placed in the air directly oppoſite to the Equator of the Earth, there will be produced one Repreſentation thereof: if poſited in the Axis, or Semiaxis there will ariſe different Repreſentations; and hence it is, that in the Projection of the Sphere (which is only the Repreſentation thereof upon a Plain) the Equator, Meridians, Parallels, &c. have various and different Repreſentations.

Secondly, You muſt conſider the Cauſe of the Variety in the largeneſs of theſe Tables or Repreſentations.

The Superficies of the Earth, Churches, Houſes, *&c.* may be drawn or repreſented either in large, or in little. The Cauſe of which is twofold.

1. By how much the Eye is further diſtant from the Object, (the Poſition of the Diaphane remaining the ſame) by ſo much is the repreſentation of the Object leſſer.

2. By how much the Diaphane is poſited nearer to the Eye, the repreſentation or Projecture is leſſer, and the nearer this Diaphane is to the Object (the Eye remaining in the ſame poſition) the greater is the Repreſentation of the ſame.

But if the eye (the Diaphane remaining in the ſame Poſition) be removed any where, (provided it be in the ſame line with the Center of the Earth, or in any line perpendicular to the Surface of it) then the Figure of the Projecture i not changed, but the Size or Magnitude of the Figure is different. Alſo if the Table or Diaphane be removed any where either towards the Eye or the Object, then ſhall all the Projectures or Repreſentations be of different Magnitude

de, and yet all of them shall be like each other: that is, (in relation to the Projection of the Superficies of the Earth) all the Places shall have a like Position with that of the Prototype, provided that the Table in it's accession to or receding from the Eye, keep in a parallel Position. But if the Table be not in a parallel Position, and the Eye be moved to any Oblique Position, all the Projectures thence arising shall not be like; nor shall the Places in the Table, have the same Situation as in the Prototype, but shall be much different both in size and Similitude.

In the Projectures of all Bodies, as also in that of the Surface of the Earth, the Diaphane or Table is alwayes so to be posited, that it may touch the Surface in that point, to which a right line drawn from the Eye is perpendicular to the Surface of the Earth: and for drawing the Projecture greater or lesser, we must suppose the Eye to be moved further from or nearer to the Earth. But then we must admit the Earth to be very small.

Thus having explained the nature of Projecting the Surface of the Earth, from whence the Original of all Geographical Charts is taken, we will enter upon the Methods of performing it. But first You must consider whether all these Geographical Tables must be made according to the Rules of Perspective, and whether they be so or not. For the design of all Maps is to give a lively Representation of the Position of Places upon the Surface of the Earth; therefore we may not unfitly enquire whether this may not be effected without observing the Rules of Perspective? For

whether these Maps be drawn according to the Rules of Perspective, or without any regard had to those Rules (provided that the Position of all Places be truly represented) then Maps so drawn are said to be well done. To this it may be answered, That small Maps, *viz.* of some Province or the like, may be projected by a Method different from the Rules of Perspective, *viz.* by Angles of Position of Places, or by their mutual distances from one another: but all the Maps which contain a large portion of the Surface of the Earth, cannot more conveniently be performed, than by the Rules of Perspective, commonly called the Projection of the Sphere.

In the Projection of Maps, there are these things to be considered. First, that all Places have the same Situation in Your Maps, as they have upon the Globe it self, that is, that they may be under the same Meridians, Parallels, and distance from the Equator in Your Map, as they are from the Equator of the Earth, *Secondly*, the Extent of all Country's upon Your Maps, have the same Proportion, as on the Earth it self, *Thirdly*, that all Places have the same situation and distance one from another, as they have upon the Surface of the Earth.

The first of these three Considerations may be exactly performed by help of a Table of Latitude and Longitude of Places: the second cannot so accurately be done if we follow the Rules of Perspective, because those parts of a Curved Surface which are more remote from the Eye do make a lesser Representation in the Diaphane than those which are nearer to it; but this Inequality

lity is small and insensible, if the Eye be supposed to be of an infinite distance from the Earth. And as to the third Consideration, I say that all large Maps, as those of the whole Earth, and those of the four Parts thereof cannot perform the Business exactly, altho' in small Maps this Third Consideration may in some measure be effected: this Explication being rightly understood, we come to put these precepts in practice.

First, to draw a Map of the World, from the Position of the Eye in the Axis thereof.

FIG. 28.

LET it be required to draw the Meridians and Parallels of a Map, which shall contain half of the Surface of the Earth, viz. that Hemisphere which is contained bewteen the Equator and the North or South Poles of the World.

For the effecting whereof, let us suppose the Eye to be placed some where above the Hemisphere, exactly over the middle point thereof, which represents one of the Poles of the World, so shall the Eye, the Pole, and Axis of the World be all three in one direct line; and so shall the Plain of the Equator (or that Plain parallel to it,) which toucheth the Hemisphere in the Pole point, represent the Diaphane, or transparent Medium.

Then let us suppose that from all the Places or points in the Peripherie of the Hemisphere there are lines drawn to the Eye cutting this Diaphane

phane in ſeveral points, which points duly
ved ſhall give the Image or Repreſentation
Hemiſphere: Thus if You take ſeveral poi
the Diaphane, which ariſe from the lines
from ſeveral points in the Tropic to the Eye
lines will when duly joyned repreſent the Peri
of the Tropic. And in this method, it
dent that the Equator is the Term of Proje
and that the Pole of the Earth is Repreſente
the Centre of this Circle, or Equator: th
Meridians (all paſſing through the Pole of
World even to the Equator) are all ſtr
lines; and that all Parallels of Latitude, T
pics, Polars, &c. do by this way of Proje
become Circles, whoſe common Centre is
Pole of the World.

And ſeeing that the Longitude and Latitu
any Place is determined by the interſection
Meridian and Parallel of that Place, therefo
the interſection of the Meridians and Paralle
the Optic Hemiſphere may the Longitudes
Latitudes of Places be truly repreſented upon
Projection. All other Peripheries and Semi
pheries which have not the Pole of the W
for their Centre, and are to be drawn
this Hemiſphere, are not right lines, nor Cir
but Ellipſes.

For if it be required to draw the Horizo
any Place and any of the vertical Circles, th
they muſt be drawn almoſt like Arches of an
Ellipſis; for when a Circle is ſeen from any o
que Poſition of the Eye, it can never appear
unto an Ellipſis; the reaſon whereof is this,
in an Ellipſis, tho' the two Diameters be uneq

the two Semidiameters, I mean the two Semidiameters of the Conjugate, or Transverse Diameters are equal; but in the Optic Projection Circle, the two Semidiameters of these Diameters are unequal.

For the clearer understanding of this kind of Projection we must suppose there is an Optic Pyramid, usually called a Cone, whose vertex reacheth to the Center of the Eye, and whose Base is that Circle of the Earth which is required to be projected; the Sides of this Cone Rayes drawn from the Periphery of the Circle to be projected, and continued to the Eye. We must also suppose this fictitious Cone to be cut by the Diaphane or transparent Medium: and according to the different position thereof there ariseth a different Section and line, which is the picture of the given Circle. Thus the Ecliptic it self, ½ whereof is contained under the Artic Hemisphere, the other ½ under the Antartic, must be projected like as a part of an Ellipsis. Having sufficiently explained the Method of these sorts of Maps, I shall proceed to the Projection thereof.

FIG. 28.

Let P the middle point represent the Pole of the World, from whence as from a Center let there be described a Circle of what Radius you please, which shall represent the Equator; and in this Center and the Circumference from thence described, are all other points to be taken. Divide this outward Circle into 360°. 00′. so

shall

shall right lines drawn from the Pole and p[…] through these points, represent Meridian[s …] that Meridian which passeth through the [begin-]ning of the first Degree shall be taken for the [first] Meridian, and so shall the other lines repre[sent] the remaining Meridians of the Earth, and [Lon-]gitudes from the first Meridian. But in this [case] it is sufficient to express only every 10th [Meri-]dian, as You see in the Figure, P. 10. P. 20. P. 3[0] in the Quadrant AB.

To delineate the Parallels of Latitude, [lay a] Ruler on D and on each 10th Degree in the [Qua-]drant BC, and draw lines as you see in the F[igure,] which shall cut the Diameter AC in 10. 2[0.] &c. then from P with the distance P. 10. P. 20. [&c.] strike the Circles, which shall represent the [Pa-]rallels of Latitude required.

Then because the Tropics are 23°. 30′ [distant] from the Equator, and the Polar Circle[s 23°.] 30′ from the Poles, therefore to describe [these] two Parallels set 23°. 30′ from A to [E, and] draw DE to cut AC in G. from P wi[th the] distance PG strike a Circle which shall rep[resent] the Tropic of Cancer. Also set 23°. 30′ [from] B to H a Ruler on DH will cut the line AC [in I,] from I with the distance PI strike a Circle, [which] shall represent the Artic Circle.

The Meridians and Parallels being thus d[rawn,] by help of a Table of the Latitude and L[ongi-]tude of Places, we may insert the Places th[em-]selves into the Map. Thus, from the first [Meri-]dian, count in the Equator the Longitude o[f the] place you desire to express in the Map, to [and] thereby find the Meridian of that Place, [and]

shall

mongst the Parallels find the Latitude of that lace, and in that point where the Meridian cuts he Latitude, is the place to be put, the name l ereof ought to be also exprest.

To project the Semicircle of the Ecliptic we ust find three points through which the Ambit the Ecliptic must pass: the first point is at terfection of the first Meridian with the E ua- or, at A: the second point is at the intersection the same, 180°. distant from the former at C, nd the middle point is that in which the Meri- an cuts the Tropic of Cancer, *viz.* at K. thus ave we three points A. K. C. through which ust be drawn that portion of the Ellipsis requi- d, and is less than ½ the Ellipsis: but these ree points do pass through the beginning of ries, the beginning of Cancer, and the beginning *Libra*, then we must find the first point of *aurus, Gemini, Leo, Virgo*, through which the cliptic must also pass; but the greater number points we have given in the Ambit an Ellipsis, the more accurately may the Fi- re be drawn; therefore let us take every 15th, egree of the Ecliptic, and by the following able of the Sun's Right Ascension and Declina- on, find the right Ascension and Declination r the 15th, and 30th, of *Aries, Taurus, Gemini*, &c. hich from the aforesaid Table will appear to be follows — *viz.*

		Right Ascension.		Declina
		D.	M	D. M
Aries	15	13.	48	5. 56
Taurus	0	27.	54	11. 30
Taurus	15	42.	31	16. 21
Gemini	0	57.	48	20. 12
Gemini	15	73.	43	22. 39
Cancer	0	90.	00	23. 30
Cancer	15	106.	17	22. 39
Leo	0	122.	12	20. 12
Leo	15	137.	29	16. 21
Virgo	0	152.	06	11. 30
Virgo	15	166.	12	5. 56

Then in the Equator find these Degre Right Ascension, and from P the Pole o World draw lines to each of the respective grees; Lastly, from the graduated Semidi ter AC, take the responding declinations, w applyed to these lines, will give you a co tent number of Points through which the A of the Elliptic Segment must be drawn, joyn these points by a neat arching line, so you projected the Hemisphere of the Eclipt

So have I compleated the projecture of one misphere of the Globe, and the other Hemisp (like to this in every part) must be effected the same manner.

Now having discoursed of the projection this sort of Maps, we will enquire into the thereof, and whether or no it be clogged w inconveniences.

Th

This Map does exactly shew the Latitudes and Longitudes of Places, also the distance of places from any of the Zones; but the due proportion of the Magnitudes of Countries it does not rightly exhibit; because those Countries which are near to the Equator do receive a larger projection than those that are more remote from it. But this defect has one convenience attends it, *viz.* that Places may be more distinctly inserted, and that there are but a few Places habitable near the Pole, whereas near the Equator there are many.

Note, That a right line drawn between any two Places upon these Maps, will represent an Arch of a great Circle, passing over the Zenith of these two Places; and also will exactly shew the Latitude and Longitude of all Places over which it passeth, even as upon the Globe it self; but the Position and Distance of Places from one another cannot be found by them.

Secondly, To draw a Map of the World from the position of the Eye in the Plane of the Equator.

FIG. 29.

THE foregoing Method of the Construction of Maps lying under so many inconveniences, as the unequal proportion and situation of places; the difficulty of conceiving the Pole of the World to fall in the Centre thereof, &c. I shall substitute another way far more agreeable and useful.

For the true and perfect apprehension of this Method,

shall right lines drawn from the Pole and through these points, represent Meridians, that Meridian which passeth through the beginning of the first Degree shall be taken for the Meridian, and so shall the other lines represent the remaining Meridians of the Earth, and Longitudes from the first Meridian. But in this it is sufficient to express only every 10th Meridian, as You see in the Figure, P. 10. P. 20. P. 30 in the Quadrant AB.

To delineate the Parallels of Latitude, lay a Ruler on D and on each 10th Degree in the Quadrant BC, and draw lines as you see in the Figure, which shall cut the Diameter AC in 10, 20, &c. then from P with the distance P. 10. P. 20. strike the Circles, which shall represent the Parallels of Latitude required.

Then because the Tropics are 23°. 30 from the Equator, and the Polar Circles 23°. 30 from the Poles, therefore to describe the two Parallels set 23°. 30 from A to E, draw DE to cut AC in G, from P with the distance PG strike a Circle which shall represent the Tropic of Cancer. Also set 23°. 30 from B to H a Ruler on DH will cut the line AC in I, from I with the distance PI strike a Circle, which shall represent the Artic Circle.

The Meridians and Parallels being thus drawn, by help of a Table of the Latitude and Longitude of Places, we may insert the Places themselves into the Map. Thus, from the first Meridian, count in the Equator the Longitude of the place you desire to express in the Map, so may thereby find the Meridian of that Place, and

mongst the Parallels find the Latitude of that place, and in that point where the Meridian cuts the Latitude, is the place to be put, the name thereof ought to be also exprest.

To project the Semicircle of the Ecliptic we must find three points through which the Ambit of the Ecliptic must pass: the first point is at intersection of the first Meridian with the Equator, at A: the second point is at the intersection of the same, 180°. distant from the former at C, and the middle point is that in which the Meridian cuts the Tropic of Cancer, *viz.* at K. thus have we three points A. K. C. through which must be drawn that portion of the Ellipsis required, and is less than ½ the Ellipsis: but these three points do pass through the beginning of Aries, the beginning of Cancer, and the beginning of *Libra*: then we must find the first point of *Taurus, Gemini, Leo, Virgo*, through which the Ecliptic must also pass; but the greater number of points we have given in the Ambit of an Ellipsis, the more accurately may the Figure be drawn; therefore let us take every 15th, degree of the Ecliptic, and by the following Table of the Sun's Right Ascension and Declination, find the right Ascension and Declination of the 15th, and 30th, of *Aries, Taurus, Gemini, &c.* which from the aforesaid Table will appear to be as follows — *viz.*

		Right Ascension.		Declina[tion]	
		D.	M	D.	M
Aries	15	13.	48	5.	56
Taurus	0	27.	54	11.	30
Taurus	15	42.	31	16.	21
Gemini	0	57.	48	20.	12
Gemini	15	73.	43	22.	38
Cancer	0	90.	00	23.	30
Cancer	15	106.	17	22.	39
Leo	0	122.	12	20.	12
Leo	15	137.	29	16.	23
Virgo	0	152.	06	11.	30
Virgo	15	166.	12	5.	56

Then in the Equator find these Degre[es of] Right Ascension, and from P the Pole o[f the] World draw lines to each of the respective [De-]grees; Lastly, from the graduated Semidi[ame-]ter AC, take the responding declinations, w[hich] applyed to these lines, will give you a co[mpe-]tent number of Points through which the A[rch] of the Elliptic Segment must be drawn, [and] joyn these points by a neat arching line, fo[r] you projected the Hemisphere of the Eclip[tic].

So have I compleated the projecture of one [He-]misphere of the Globe, and the other Hemisp[here] (like to this in every part) must be effected [in] the same manner.

Now having discoursed of the projectio[n of] this sort of Maps, we will enquire into the [use] thereof, and whether or no it be clogged w[ith] inconveniences.

Th[e]

This Map does exactly shew the Latitudes and Longitudes of Places, also the distance of places from any of the Zones; but the due proportion of the Magnitudes of Countries it does not rightly exhibit; because those Countries which are near to the Equator do receive a larger projection than those that are more remote from it. But this defect has one convenience attends it, *viz.* that Places may be more distinctly inserted, and that there are but a few Places habitable near the Pole, whereas near the Equator there are many.

Note, That a right line drawn between any two Places upon these Maps, will represent an Arch of a great Circle, passing over the Zenith of these two Places; and also will exactly shew the Latitude and Longitude of all Places over which it passeth, even as upon the Globe it self; but the Position and Distance of Places from one another cannot be found by them.

Secondly, To draw a Map of the World from the position of the Eye in the Plane of the Equator.

FIG. 29.

THE foregoing Method of the Construction of Maps lying under so many inconveniences, as the unequal proportion and situation of places; the difficulty of conceiving the Pole of the World to fall in the Centre thereof, *&c.* I shall substitute another way far more agreeable and useful.

For the true and perfect apprehension of this Method,

Method, we must conceive the Superficies of the Earth to be cut into two Hemispheres by the Periphery of the first Meridian; the Eye must be posited in a point of the Equator 90 Degrees distant from the first Meridian: the Diaphane or transparent Medium in which the representation is to be made, we suppose to be the Plane of the first Meridian: Lastly, that Hemisphere, which in respect of our Eye, lies below that Plane, is said to be represented in that Plane.

In this projection of the Superficies of the Earth the Semicircle of the Equator is become a right line: and that Meridian which is 90 degrees distant from the first, and in which the Eye is supposed to be posited, must likewise be represented by a right line; but the other Meridians and all the parallels of the Equator, become Arches of Circles.

The Construction.

Upon E (as a Centre) with any extent, describe a Circle which shall represent the first Meridian, as ABCD, and the line BED shall represent that Meridian which is 90°. 00′. distant from it: also B represents one of the Poles of the World, and D the other: the Diameter AC, at right angles to BD, represents the Equator, and E the point of the Eyes position. Thus we have the first Meridian divided into 4 Quadrants, as AB, BC, CD, DA, each of which quadrants must be divided into 90°. 00′.

First, the line AC, representing half the Equator must be divided into 180 degrees, after this

manner

manner, lay a Ruler upon D, and upon each Degree, (or rather each 10th Degree) in the Quadrant AB, so shall the side of this Ruler cut the Quadrant of the Equator A E in H. I. K. L. M. N O. P: and in like manner may the other Quadrant of the Equator be divided. This Division of the Equator, is the same with the Divisions upon a line of half Tangents, and the Arch EP is the half Tangent of 10°. EO of 20°. EN of 30°. &c. But if DE be the Radius of a Circle, then EP will be the Tangent of 5°. EO the tangent of 10°. and EA the tangent of 45°. &c. for by 20. 3. Euclid, an angle at the Center VEB is double to an angle at the Circumference VDB, therefore having the two Poles, and the Points H. I. K. L. &c. given, we may describe the Circumference of a Circle which shall pass through these points, and the Circumference so described shall represent the Meridians of this Chart. Thus, suppose the Center of the Meridian BHD, (passing through the first 10°. of Longitude) be required. Seek in the line EC, for the Tangent of 10° which is at Q, so shall Q be the Center required; then from Q strike the Meridian BHD. from R. the Meridian BKD. &c. and after this manner may all the Meridians be described; and the Centers of all those Meridians, whose distance from the first Meridian BAD is less than 45°. may be found in the line EC: or AE; but the Centers of those which are more than 45°. distant from BAD must be found in the lines EC, AE continued thus, the Center of the Meridian BMD, 50°. distant from BAD, may be found by laying a ruler on B and

W to

W to cut EC (continued) in X. So shall X be the Center from whence the Meridian BMC must be drawn. The reason whereof is evident from the Figure; for if AE be the Radius of the Circle, and from B be described an Arch with that Radius, and upon this Arch you set 90. then a line from B through the term of this Arch will cut the Circle in W, and the Diameter AC (continued) in X. So the same also may be done ... each an degree ... shall the whole ... CW ... Tangent EX ... the ...

The construction ... jection: Divi... BED, after the ... Diameter AC, ... Divisions in A... Centers of all ... fall in the line ... on Centers ... viz. ... which is at ...

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Upon C the end of the Diameter, erect a Perpendicular Cc. which shall be a Tangent line to the primitive Circle: from E through each Degree in the Quadrant BC draw lines, as EW, EY, EZ, En, Eb, &c. and in this Tangent line Cc so divided may be found the Center of all the Meridians, for CW. shall be equal to EQ, CY to ER, CZ to ES, &c.

Also all those lines drawn from the Center E through each degree in the Quadrant Bc shall be Secants, as EW is the Secant of the first 10 degrees

grees, which applyed from E upon the line EB shall give the Center of the parallel V 80 V: EY transferred into EC shall give the Center of the parallel d 70 d, and EZ applyed as afore, shall give the Center of the parallel e 60 e, the like is to be understood of all the rest.

And after this manner were the Polar Circles [illegible] ed, as you see in the Figure, [illegible] fferent methods of describing [illegible] is projection, according as [illegible] tion thereof either upon, or [illegible] that its Intersection with the [illegible] hrough the point E, which [illegible] f *Aries*; and in this position [illegible] he Semicircle of the Eclip- [illegible] beginning of *Cancer*, to the [illegible] *orn*, is a right line: and be- [illegible] stance of the Ecliptic from [illegible] . 3', therefore from this [illegible] ne FEG to represent the [illegible] Ecliptic according to this [illegible] ; and if you divide this line FG as you [illegible] d the Equator AC, you may number upon it the Degrees of each Sign.

But if you design the Intersection of the Meridian and Equator to be at A in the first Meridian, then the projection thereof becomes a portion of an Ellipsis, whose two points are A. C. and the third is that in which the Meridian BED cuts the Tropic of *Cancer, viz.* at [illegible], the other intermediate points, through which the Ecliptic must pass, may be found according to the directions in the preceding method of projecting the Sphere, *viz.* by the right Ascensions

W. to cut EC (continued) in X. So shall X be the Center from whence the Meridian BMC must be drawn. The reason whereof is evident from the Figure, for if AE be the Radius of the Circle, and from B be described an Arch with that Radius, and upon this Arch you set 50°. then a line from B through the terme of this Arch will cut the Circle in W, and the Diameter AC (continued) in X. so The same also may be done by counting each 10 degrees in the Quadrant DC for 100. So shall the whole DC contain 145°. to which add CW 55°. and the Arch DW will be 90°. whose Tangent is EX, the like is to be understood of all the rest.

The construction of the Parallels of Latitude is thus: Divide the Quadrants of the Meridian BED after the same manner as you divided the Diameter AC, or which is all one, transfer the Divisions in AE into the line EB. ED. then the Centers of all the Parallels, Tropics and Polars will fall in the line EB continued; and these points or Centers may be discovered as followeth, *viz.*

Upon C the end of the Diameter, erect a Perpendicular Cc. which shall be a Tangent line unto the primitive Circle: from E through each Degree in the Quadrant BC draw lines, as EW. EY. EZ. Ea. Eb. *&c.* and in this Tangent line Cc so divided may be found the Center of all the Meridians, for CW. shall be equal to EQ. CY to ER. CZ to ES, *&c.*

Also all those lines drawn from the Center E through each degree in the Quadrant Bc shall be Secants, as EW is the Secant of the first 10 degrees

grees, which applyed from E upon the line EB shall give the Center of the parallel V 80 V: EY transferred into EC shall give the Center of the parallel d 70 d, and EZ applyed as afore, shall give the Center of the parallel e 60 e, the like is to be understood of all the rest.

And after this manner were the Polar Circles and Tropics described, as you see in the Figure.

There are two different methods of describing the Ecliptic by this projection, according as you design the situation thereof either upon, or above the Earth, so that its Intersection with the Equator may pass through the point E, which is the first point of *Aries*; and in this position the projecture of the Semicircle of the Ecliptic, *viz.* from the beginning of *Cancer*, to the beginning of *Capricorn*, is a right line: and because the greatest distance of the Ecliptic from the Equator is 23°. 31′, therefore from this point draw the line FEG to represent the Semicircle of the Ecliptic according to this method; and if you divide this line FG as you did the Equator AC, you may number upon it the Degrees of each Sign.

But if you design the Intersection of the Meridian and Equator to be at A in the first Meridian, then the projection thereof becomes a portion of an Ellipsis, whose two points are A. C. and the third is that in which the Meridian BED cuts the Tropic of *Cancer*, *viz.* at E, the other intermediate points, through which the Ecliptic must pass, may be found according to the directions in the preceding method of projecting the Sphere, *viz.* by the right Ascensions

ſions and Declinations of each 15*th* Degree in the Ecliptic. After this way is the Ecliptic actually projected upon ſuch Maps as are drawn upon two equal Hemiſpheres, one Semicircle thereof being drawn in the one, and the other Semicircle, in the other Hemiſphere.

The projection being thus compleated, the known Latitudes and Longitudes of places may eaſily be inſerted therein for that point where the Parallel of the Latitude of any place cuts the Meridian of Longitude of the ſame place, is the true repreſentation thereof.

By this artifice alſo may the whole Surface of the Earth be exhibited in one Map, if inſtead of the place of the firſt Meridian, you ſubſtitute another Plane parallel to it, and the poſition of the eye be very near this ſubſtituted Plane, which in this caſe muſt repreſent the Diaphane or tranſparent Medium: for ſo the Parallels and Meridians may be continued, whereas now they do not exceed a Semicircle: but then the repreſentation would be much different from the true Surface of the Earth; and its uſe appearing far more convenient for determining all hour-diſtances upon Dyal-Plains, than for Geography, I omit to explain it further.

The uſe of this kind of Projection, I mean the meaſuring the poſitions and diſtances of places cannot conveniently be determined by these Maps, unleſs one of the places be poſited under the firſt Meridian, which how to perform, I may perhaps hereafter give ſome particular Rules, for an abſolute Projection of the Sphere.

I have

I have now explained (so far as my present design required) the construction of some Circular Maps or Charts, according to the rules of Perspective, I proceed to the construction of Right-lined Maps, which for Sea purposes are far more convenient than the former.

Of Right-lined Maps.

Right-lined Maps are such whose Meridians and Parallels are all right lines; and consequently (according to the Rules of Optics) cannot give an express Image of the Prototype; for there can be no position of the eye, or medium, wherein both these Species of Circles, viz. the Meridians and Parallels can become right lines.

In Figure the 28th it was demonstrated that the Meridians were all of them right lines, and that by Rules of Perspective: and in the same place it appears that the Parallels of Latitude are all of them Circles, not right lines. Charts of different construction from those I have here explained may be made, but then altho the Parallels of Latitude be right lines, the Meridians will become Elliptical. Others may have their Meridians right lines; but then the Parallels will be Hyperbola's, viz. when the eye is posited in the Center of the Earth, and views an Hemisphere from either part of the first Meridian; the transparent medium through which the visual Rays pass from the Object to the eye, being a plain parallel to the first Meridian: and all these several kinds are drawn by Rules of Perspective, but all those

those Maps whose Meridians and Parallels are ri[ght] lines, their Construction does oppose these Ru[les]

Of these there are two Kinds. One [of] them consisting upon this Hypothesis, viz. th[at] the Degrees of Latitude, and Longitude in ev[e]ry part are equal one to another. The other [of] them making the Degrees of Longitude in all Pla[]ces, equal one to another, but the Degrees [of] Latitude unequal. The Degrees of Latitude [in]creasing continually from the Equator to t[he] Poles, so that in the Latitude of 60°. [a] Degree in the Meridian is equal to two Deg[rees] of the Equator, in the Latitude of 80°. to [] thereof, and in the Degrees of the Merid[ian] near to the Poles, are almost infinite. The fi[rst] of these is commonly called the Plain Ch[art] which as I told You before, took it's Origi[nal] from that erroneous Notion of the Ancients, [] that the form of the Earth was like to a large [ex]tended Circular Plain, as that of a Round Ta[ble] founded upon a Basis infinitely continued do[wn]wards; hence Charts or Maps delineated a[c]cording to this Hypothesis are usually cal[led] Plain. By this Chart, it is evident that [the] North and South lines drawn thereupon can[not] pass through the Poles of the World. A[nd] therefore cannot truly be called Meridia[ns]. Also by this it appears that each Parallel of [La]titude is equal to the Equator. How disagree[a]ble this Hypothesis is, and how repugnant [to] Reason, may be thus apprehended.

If the Form of the Earth and Sea be a large ex[]tended circular Plain, then at the verge or li[]mits thereof must be a Precipice impassable. []

r Ships having Sailed over most parts of the
, *viz.* from North to South, and by conti-
ing an Eastward Course have arrived at the
e Place from whence they began to sail,
thout discovering any such Precipice; there-
e I say that Hypothesis is contrary to experi-
ce: and that the same is repugnant to reason,
y thus be argued. If the Earth be sustained
on a Basis infinitely continued downwards, this
sis must not only reach to the Heavens, but
ewise pass through them; and so proceed to
finity, but this Basis as they called it, must be
ible in the time of the Lunar Eclipsis, for the
dow of the Earth reacheth thither, and
re the shadow of this infinitely long han-
e, must at those times be visible or apparent
us; but this hath hitherto been invisible: *Ergo*,
such thing in nature. A great number of
rguments may be produced to break down this
ng Pedestal, which I forbear to mention, hope-
g my Reader will rather in such Cases make
e of his own reason in enquiring the truth,
an pin his Faith on the Sleeve of Antiquity.

And tho' this Chart depend upon a false supposi-
on, yet seeing our Seamen are not willing to lay
ide the practice of their Fore-Fathers in conti-
uing the use of this Chart, I shall first shew
's Construction, and then proceed to the use
hereof.

The Construction of the Plain Chart.

FIG. 29.

These Charts are either general or particu[lar], and the construction of either of them is [as] follows.

Draw the line AB for the Equator in a ge[ne]ral Chart; divide this line into 180 equal p[arts] or Degrees, and through each Degree, or e[very] 10*th* Degree draw perpendicular lines, w[hich] shall represent the Meridians of this Chart. D[i]vide these Meridians into 90 equal parts or D[e]grees, beginning that Division at the Equ[ator] AB, and proceeding from thence both to [the] Northward and the Southward thereof, each [Di]vision in the Meridian being equal to each in [the] Equator, then through each 10*th* Degree in [the] Meridian, draw lines Parallel to the Equat[or] which shall represent the parallels or Circ[les] of Latitude, as the Meridian did represent t[he] Circles of Longitude.

Lastly, because the World (according [to] this Hypothesis) is a Circular plain, there[fore] from C strike the Circle ADBE, which shall [re]present the Figure of the Earth with all its M[e]ridians and Parallels contained therein. Upon t[his] Chart you may (by help of a Table of Latit[ude] and Longitude of places) insert the said place[s].

But seeing (according to this Chart) that t[he] Meridians have no inclination one to another, b[ut] are all parallel to each other, and divided equally [as] is the Equator, therefore if you insert these pla[ces] according to their true Latitudes and Longitude[s]

th[e]

hen shall their Course and Distance disagree with he Globe; and if you set these places upon his Chart according to their Latitude and Diance, then will their Course be true, but their ongitude always erroneous, as shall be explained the use of the True Sea Chart.

The Construction of the particular plain Chart the same with that of the general, as you may e in Fig. 33. where every Degree of Latide is equal to each Degree of Longitude, and ffers only in it's extent from that of the genel.

The other sort of right Lined Maps which or the perpetual reputation of the first inventr, our famous Countryman Mr. *Edward Wright*) ght to be called *Wright*'s Charts, and not *ercator*'s, who only stole the Invention from the uthor, and published them in his own Name, ose Charts do (as the former) divide the Equator to equal parts called Degrees; and have all e Meridians at right Angles to the Parallels of titude, but the division of the Meridians (by e Circles of Latitude) are much different from e division of the Meridians in the plain Chart. r, the degrees of the Meridian are not equal t unequal, as I noted before; and do continuy encrease from the Equator towards both the les.

This curious contrivance, the Ingenious Auor thereof endeavoured to accomplish upon this ry occasion, *viz.* He considered how all other aps, whose Construction depended upon the Op projection of the Sphere, were (even the best them) unfit for the use of ordinary Seamen,

for tho' the Latitude and Longitude of Pla-
might be truly laid down upon them, yet th-
bearing and distance of Places, (being of grea-
est use to Seamen) could not possibly b-
found in some of them; and not without mu-
labour and Art, in others of them: and ther-
upon he applyed himself to the discovery of su-
a Construction, as might not only shew the La-
tude and Longitude of Places, but also th-
bearing and distance, in right Lines.

The Construction is as followeth.

FIG. 70.

The Meridians (through every degree of th-
Equator) are drawn mutually parallel, and a-
the Circles of Latitude parallel to each oth-
and also to the Equator, the degrees of the Me-
dians encreasing continually from the Equato-
hence it is, that Places posited in every of th-
Meridians, are removed so much farther abov-
their true distance from the first Meridian, b-
how much they are more remote from the Equ-
tor. That is, that in these Charts, the distan-
of Places from the first Meridian, does so mu-
exceed the just distance, as the Semidiameter o-
the Earth, exceeds the Semidiameter of any Pa-
rallel; or as the whole Sine exceeds th-
Sine Complement of any Parallel of Latitud-
And what proportion the whole Sine (or Rad-
us of the Earth) bears to the Co-Sine of the La-
titude of any Place, the same proportion do-
one Degree in the Equator bear to one Degre-
in a Circle of that Latitude or Parallel.

It appears from the Globe, that a degree in a-y Parallel is less than a degree in the Equator; nd that degrees in each Parallel do grow less nd less, according as that Parallel is nearer to ne Poles, as you may observe in Fig. 30. but in is admirable Contrivance, the Parallels of La-tude are each made equal to the Equator, and onsequently a degree in each Parallel must be e-ual to a degree in the Equator: therefore by ow much the Parallels themselves are encreased ove the just extension, by so much must the eridians be encreased above the extension of the quator, and by Figure 58. the proportion of y Parallel to the Equator, and of a degree in y Parallel to a degree in the Equator may be und: for let ÆQ be the Equator NP. SP the orth and South Poles of the World, and ADB y Parallel of Latitude; then it is evident that C is the Semidiameter of the Equator, and D the Semidiameter of the given Parallel; there-re, as ÆC is to AD, so is CE a degree in the uator, to DF a degree in that Parallel: and contrary; for AD bears such proportion ÆC as DF doth to EC.

Here, note that if you desire the proportion re accurately, you must not take the Sine of Complement of the Latitude of any Parallel, t the sine of the Complement of the Latitude ich begins at that degree, must be added to Sine of the Complement of that Latitude ich terminates that degree, and the half of s Sum must be the first term in the Rule of pro-rtion.

EXAMPLE 1.

Suppose it be required to find a Point in t Meridian which shall answer to the first degree Latitude, let the quantity of one degree in the quator contain 60 parts, (which elsewhere I c Sexagenary miles)

According to the first proportion the Qua ty of a degree in the Meridian for the first d gree of Latitude, will be equal to a degree the Equator, because the Equator it self is t Parallel which begins that degree: but acco ing to the second proportion I take the Co-S of 00°. 00′ of Latitude which is the Sine of 9 00′. *viz.* 100000, (for the Complement of c to 90°. is 90 degrees) and I add it to the Sin the Complement of 1°. 00′ *viz.* to the Sin 89°. 00′, which is 99985, the Sum is 199 and the ½ Sum is 99992: therefore as 99992 i 100000, so is 60 the quantity of one degre the Equator to 60 $\frac{480}{99992}$ the quantity of a deg in the Meridian for the first degree of Latit

EXAMPLE 2

Let it be required to find the length of a deg in the Meridian for the Latitude of 60°. this Parallel of 60°. is bounded by the Para of 59°. on one Side, and by the Parallel of 6 on the other Side. Then by the first of the p ceding Proportions the Sine of the Comple of 59°. 00′, is 51503, therefore as 51503 is 100000, so is 60 to 116 $\frac{17852}{51503}$ for the quan of a degree in the Latitude of 60°. 00′.

But according to the second proportion, you must look for the Sine of the Complement of 59°. which is 51503. and also for the Co-Sine of 61°. which is 48481. the Sum of these two Numbers is 99984. and the half Sum is 49992, therefore say

As 49992 is to 100000 so is 60 to 120 $\frac{960}{49992}$ the just quantity of a degree in the Meridian for the Latitude of 60°. 00′.

And thus when you have found the quantity of a degree for the Parallel of 2°. 00′, you must add it to the quantity of a degree for the Parallel of 1°. 00′ and the Sum shall give the true point in the Meridian through which the Parallel of 2° from the Equator. Again having found the quantity of a degree for the Parallel of 3°. 00′ add the same to the Sum of the quantities of 1°. and 2°. and this aggregate shall shew the term in the Meridian through which this third degree of Latitude must pass.

By this you may easily understand how the Meridian line must be encreased for the Equator towards the Poles, only by help of a Table of Natural Sines; and how to performe the same by a Table of Natural Secants (which is the method used by Mr. *Wright*) may be apprehended from this universal Theorem, *viz.*

Radius is a mean proportional between the Sine of a Arch, and the Secant of the Complement of the same Arch.

FIG. 1?.

Demonstr. the Triangles CFK, CDH are like or equiangular, becauſe of the two Parallel lines CK. DH; and by Theor. 2. 3. Chap. 6. the angle CFK is equal to the angle DCH. therefore by 2. 6. *Euclid*, as KF is to CF. ſo is CD to CH. but CD is equal to CF the Radius of the Circle, KF is the Sine of the Arch BF. and CH is the Secant of the arch DF, the Complement of BF to a Quadrant, and therefore alternately, as HC. FC : : FC. FK which was to be demonſtrated.

Hence it appears, that ſeeing the Semidiameter of each Parallel is made equal to the Semidiameter of the Equator, the Meridian at each point of Latitude muſt needs encreaſe by the ſame proportion wherewith the Secants of the Arches contained between the points of Latitude and the Equator do encreaſe.

Thus both by the Table of Natural Sines, or Natural Secants, may the diviſions of the Meridian line be expedited. For, firſt find the Secant of 1 degree of Latitude from the Equator, this ſhall give you the Section in the Meridian through which the firſt degree of Latitude muſt be drawn; then find the Secant of two degrees, which being added to the Secant of 1 degree, the Sum ſhall be the Section on the Meridian, through which the Parallel of 2 degrees muſt

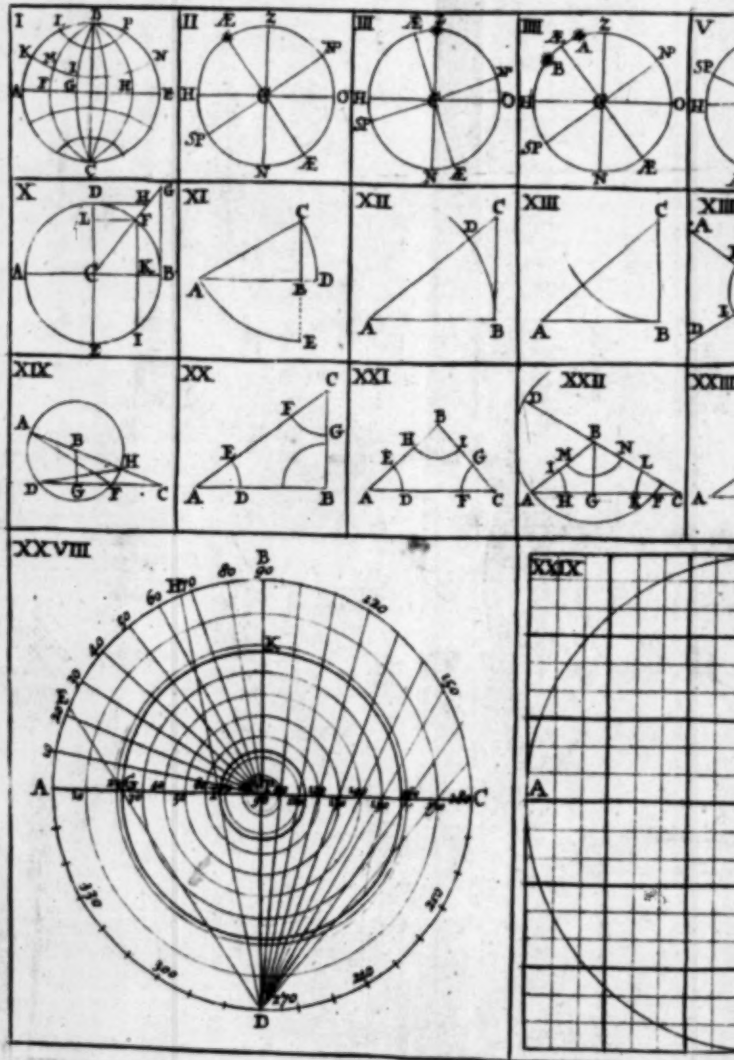
must pass. Again, find the Secant of 3 degrees, this added to the Sum of the Secants of 1°. and 2°. the Aggregrate shews the Section or point of the Meridian through which the Parallel of 3 degrees of Latitude must pass. The same you must understand of all the rest.

But to render the Idea of this contrivance more perceptible, I shall use the Author's own Illustration which is as followeth, *viz.* If a Globe be with all it's Meridians and Parallels posited in a Concave Cylinder, (their Axes mutually agreeing) be supposed to be blown like a Bladder till every part of the convex superficies of the Globe touch every part of the concave Cylinder, then shall each Parallel upon the Globe attain an equal Diameter with the Equator or Cylinder: and then shall the Meridians upon the Globe, be every where so far distant each from other, as they were at the Equator; and by this contrivance will each part in this Concave Cylinder, mutually agree with it's corresponding part in the Globe, without either sensible or explicable Errour.

For the Delineation of these Charts you must proceed thus. By the continual addition of Secants, you have a Table of Meridional parts, the Secants beginning at the Equator or Parallel of 00°. 00'. and continuing successively to the Poles, that is equally alike on both Sides of the Equator: one degree of Longitude, or of the Equator being taken for the Radius of that Circle, whose Secant shew the points of division in the Meridian Line.

The readiest method for drawing the Parallels of Latitude in those Charts is by help of a line of Secants

Secants upon a Sector, for making one degree Longitude in the Equator, (which you may t of what length you please) the Radius of a C cle, rectify the first points of the Secants up your Sector, to that distance, so shall each degr upon your Sector give you the quantity of ea degree of Latitude in the Meridian line, as shall farther explain in the use of this Chart.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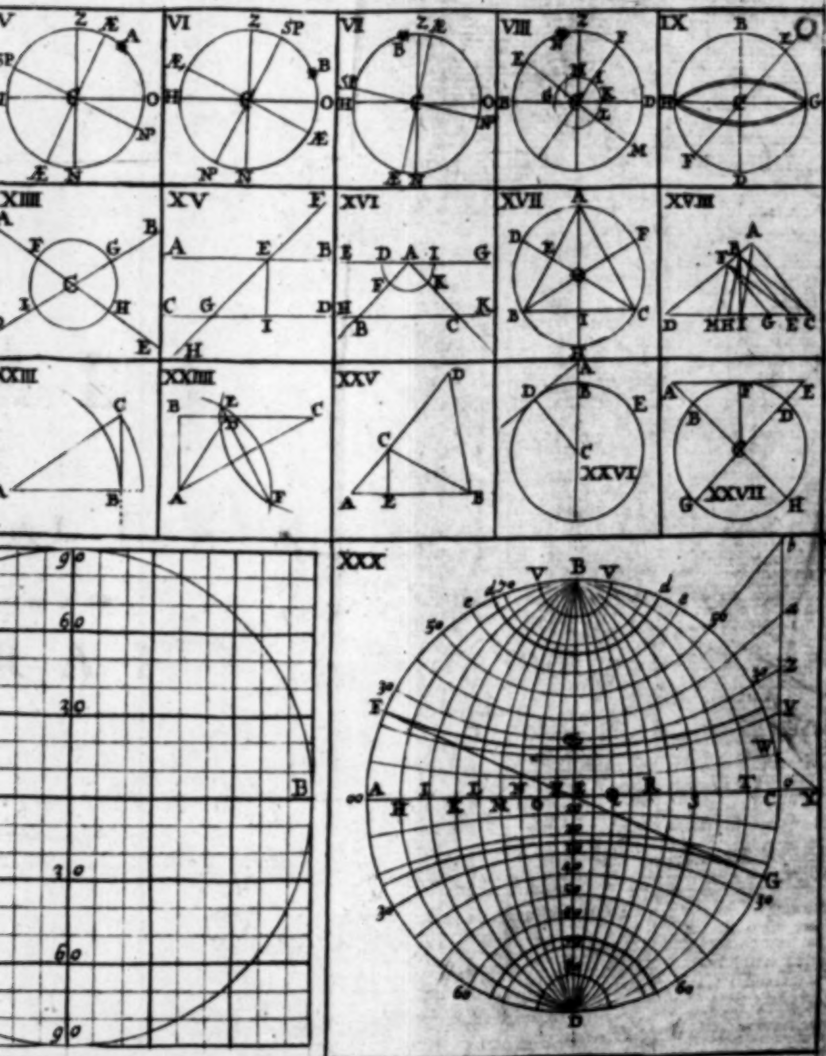

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A

TABLE

OF

MERIDIONAL PARTS

To every Minute of the

QUADRANT.

Degrees of Latitude.

M.	0	1	2	3	4	5	6
0	0	60	120	180	240	300	360
1	1	61	21	81	41	01	61
2	2	62	22	82	42	02	62
3	3	63	23	83	43	03	63
4	4	64	24	84	44	04	64
5	5	65	125	185	245	305	365
6	6	66	26	86	46	06	66
7	7	67	27	87	47	07	67
8	8	68	28	88	48	08	68
9	9	69	29	89	49	09	69
10	10	70	130	190	250	310	370
11	11	71	31	91	51	11	71
12	12	72	32	92	52	12	72
13	13	73	33	93	53	13	73
14	14	74	34	94	54	14	74
15	15	75	135	195	255	315	375
16	16	76	36	96	56	16	76
17	17	77	37	97	57	17	77
18	18	78	38	98	58	18	78
19	19	79	39	99	59	19	79
20	20	80	140	200	260	320	380
21	21	81	41	01	61	21	81
22	22	82	42	02	62	22	82
23	23	83	43	03	63	23	83
24	24	84	44	04	64	24	84
25	25	85	145	205	265	325	385
26	26	86	46	06	66	26	86
27	27	87	47	07	67	27	87
28	28	88	48	08	68	28	88
29	29	89	49	09	69	29	90

Degrees of Latitude.

M	0	1	2	3	4	5	6
30	30	90	150	210	270	330	390
31	31	91	51	11	71	31	91
32	32	92	52	12	72	32	92
33	33	93	53	13	73	33	93
34	34	94	54	14	74	34	94
35	35	95	155	215	75	335	195
36	36	96	56	16	76	36	96
37	37	97	57	17	77	37	97
38	38	98	58	18	78	38	98
39	39	99	59	19	79	39	99
40	40	100	160	220	280	340	400
41	41	01	61	21	81	41	01
42	42	02	62	22	82	42	02
43	43	03	63	23	83	43	03
44	44	04	64	24	84	44	04
45	45	105	165	225	285	345	405
46	46	06	66	26	86	46	06
47	47	07	67	27	87	47	07
48	48	08	68	28	88	48	08
49	49	09	69	29	89	49	09
50	50	110	170	230	290	350	410
51	51	11	71	31	91	51	11
52	52	12	72	32	92	52	12
53	53	13	73	33	93	53	13
54	54	14	74	34	94	54	14
55	55	115	175	235	295	355	415
56	56	16	76	36	96	56	16
57	57	17	77	37	97	57	17
58	58	18	78	38	98	58	18
59	59	19	79	39	99	59	20

Degrees of Latitude.

M.	7	8	9	10	11	12	13
0	421	481	542	603	664	725	786
1	22	82	43	04	65	26	87
2	23	83	44	05	66	27	88
3	24	84	45	06	67	28	89
4	25	85	46	07	68	29	90
5	426	486	547	608	669	730	791
6	27	87	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	28	88	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	29	89	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	30	90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	431	491	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	32	92	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	33	93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	34	94	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	35	95	56	[illegible]	78	39	[illegible]
15	436	496	557	618	679	740	802
16	37	97	58	19	80	41	03
17	38	98	59	20	81	42	04
18	39	99	60	21	82	43	05
19	40	500	61	22	83	44	06
20	441	01	562	623	684	745	807
21	42	02	63	24	85	46	08
22	43	03	64	25	86	47	09
23	44	04	65	26	87	48	10
24	45	05	66	27	88	49	11
25	446	506	567	628	689	750	812
26	47	07	68	29	90	51	13
27	48	08	69	30	91	52	14
28	49	09	70	31	92	53	15
29	50	10	71	32	93	54	16

Degrees of Latitude.

M.	7	8	9	10	11	12	13
30	451	511	572	633	694	755	817
31	52	12	73	34	95	57	18
32	53	13	74	35	96	58	19
33	54	14	75	36	97	59	20
34	55	15	76	37	98	60	21
35	456	516	577	638	699	761	822
36	57	17	78	39	700	62	23
[illegible]	[illegible]	18	79	40	01	63	24
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]1	02	64	25
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]2	03	65	26
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]43	704	766	827
[illegible]	[illegible]	[illegible]	[illegible]	44	05	67	28
[illegible]	[illegible]	[illegible]	[illegible]	45	06	68	29
[illegible]	[illegible]	[illegible]	[illegible]	46	07	69	30
[illegible]	[illegible]	[illegible]	[illegible]	47	08	70	31
45	466	527	587	648	709	771	833
46	67	28	88	49	10	72	34
47	68	29	89	50	12	73	35
48	69	30	90	51	13	74	36
49	70	31	91	52	14	75	37
50	471	532	592	653	715	776	838
51	72	33	93	54	16	77	39
52	73	34	94	55	17	78	40
53	74	35	95	56	18	79	41
54	75	36	96	57	19	80	42
55	476	537	597	658	720	781	843
56	77	38	98	59	21	82	44
57	78	39	600	61	22	83	45
58	79	40	01	62	23	84	46
59	80	41	02	63	24	85	47

Degrees of Latitude.

M.	7	8	9	10	11	12	13
0	421	481	542	603	664	725	786
1	22	82	43	04	65	26	87
2	23	83	44	05	66	27	88
3	24	84	45	06	67	28	89
4	25	85	46	07	68	29	90
5	426	486	547	608	669	730	791
6	27	87	48	09	70	31	92
7	28	88	49	10	71	32	93
8	29	89	50	11	72	33	94
9	30	90	51	12	73	34	95
10	431	491	552	613	674	735	797
11	32	92	53	14	75	36	98
12	33	93	54	15	76	37	99
13	34	94	55	16	77	38	800
14	35	95	56	17	78	39	01
15	436	496	557	618	679	740	802
16	37	97	58	19	80	41	03
17	38	98	59	20	81	42	04
18	39	99	60	21	82	43	05
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27	48	08	69	30	91	52	14
28	49	09	70	31	92	53	15
29	50	10	71	32	93	54	16

Degrees of Latitude.

M.	7	8	9	10	11	12	13
30	451	511	572	633	694	755	817
31	52	12	73	34	95	57	18
32	53	13	74	35	96	58	19
33	54	14	75	36	97	59	20
34	55	15	76	37	98	60	21
35	456	516	577	638	699	761	822
36	57	17	78	39	700	62	23
37	58	18	79	40	01	63	24
38	59	19	80	41	02	64	25
39	60	20	81	42	03	65	26
40	461	521	582	643	704	766	827
41	62	22	83	44	05	67	28
42	63	23	84	45	06	68	29
43	64	25	85	46	07	69	30
44	65	26	86	47	08	70	31
45	466	527	587	648	709	771	833
46	67	28	88	49	10	72	34
47	68	29	89	50	12	73	35
48	69	30	90	51	13	74	36
49	70	31	91	52	14	75	37
50	471	532	592	653	715	776	838
51	72	33	93	54	16	77	39
52	73	34	94	55	17	78	40
53	74	35	95	56	18	79	41
54	75	36	96	57	19	80	42
55	476	537	597	658	720	781	843
56	77	38	98	59	21	82	44
57	78	39	600	61	22	83	45
58	79	40	01	62	23	84	46
59	80	41	02	63	24	85	47

Degrees of Latitude.

M.	14	15	16	17	18	19	20
0	848	910	972	1035	1098	1161	1225
1	49	11	73	36	99	62	26
2	50	12	74	37	1100	63	27
3	51	13	75	38	01	64	28
4	52	14	76	39	02	65	29
5	853	915	977	1040	1103	1166	1230
6	54	16	78	41	04	67	31
7	55	17	79	42	05	68	32
8	56	18	81	43	06	69	33
9	57	19	82	44	07	70	34
10	858	920	983	1045	1108	1172	1235
11	59	21	84	46	09	73	36
12	60	22	85	47	10	74	37
13	61	23	86	48	11	75	38
14	62	24	87	49	12	76	40
15	863	925	988	1050	1113	1177	1241
16	64	27	89	52	15	78	42
17	65	28	90	53	16	79	43
18	67	29	91	54	17	80	44
19	68	30	92	55	18	81	45
20	869	931	993	1056	1119	1182	1246
21	70	32	94	57	20	83	47
22	71	33	95	58	21	84	48
23	72	34	96	59	22	85	49
24	73	35	97	60	23	86	50
25	874	936	998	1061	1124	1187	1251
26	75	37	99	62	25	88	52
27	76	38	1000	63	26	90	53
28	77	39	01	64	27	91	54
29	78	40	02	65	28	92	56

Degrees of Latitude.

M.	14	15	16	17	18	19	20
30	879	941	1003	1066	1129	1193	1257
31	80	42	04	67	30	94	58
32	81	43	06	68	31	95	59
33	82	44	07	69	32	96	60
34	83	45	08	70	33	97	61
35	884	946	1009	1071	1135	1198	1262
36	85	47	10	72	36	99	63
37	86	48	11	74	37	1200	64
38	87	49	12	75	38	01	65
39	88	50	13	76	39	02	66
40	889	951	1014	1077	1140	1203	1267
41	90	52	15	78	41	04	68
42	91	53	16	79	42	05	69
43	92	55	17	80	43	07	70
44	93	56	18	81	44	08	72
45	894	957	1019	1082	1145	1209	1273
46	95	58	20	83	46	10	74
47	96	59	21	84	47	11	75
48	98	60	22	85	48	12	76
49	99	61	23	86	49	13	77
50	900	962	1024	1087	1150	1214	1278
51	01	63	25	88	51	15	79
52	02	64	26	89	52	16	80
53	03	65	27	90	54	17	81
54	04	66	29	91	55	18	82
55	905	967	1030	1092	1156	1219	1283
56	06	68	31	93	57	20	84
57	07	69	32	95	58	21	85
58	08	70	33	96	59	22	87
59	09	71	34	97	60	24	88

Degrees of Latitude.

M.	14	15	16	17	18	19	20
0	848	910	972	1035	1098	1161	1225
1	49	11	73	36	99	62	26
2	50	12	74	37	1100	63	27
3	51	13	75	38	01	64	28
4	52	14	76	39	02	65	29
5	853	915	977	1040	1103	1166	1230
6	54	16	78	41	04	67	31
7	55	17	79	42	05	68	32
8	56	18	81	43	06	69	33
9	57	19	82	44	07	70	34
10	858	920	983	1045	1108	1172	1235
11	59	21	84	46	09	73	36
12	60	22	85	47	10	74	37
13	61	23	86	48	11	75	38
14	62	24	87	49	12	76	40
15	863	925	988	1050	1113	1177	1241
16	64	27	89	52	15	78	42
17	65	28	90	53	16	79	43
18	67	29	91	54	17	80	44
19	68	30	92	55	18	81	45
20	869	931	993	1056	1119	1182	1246
21	70	32	94	57	20	83	47
22	71	33	95	58	21	84	48
23	72	34	96	59	22	85	49
24	73	35	97	60	23	86	50
25	874	936	998	1061	1124	1187	1251
26	75	37	99	62	25	88	52
27	76	38	1000	63	26	90	53
28	77	39	01	64	27	91	54
29	78	40	02	65	28	92	56

Degrees of Latitude.

M.	14	15	16	17	18	19	20
30	879	941	1003	1066	1129	1193	1257
31	80	42	04	67	30	94	58
32	81	43	06	68	31	95	59
33	82	44	07	69	32	96	60
34	83	45	08	70	33	97	61
35	884	946	1009	1071	1135	1198	1262
36	85	47	10	72	36	99	63
37	86	48	11	74	37	1200	64
38	87	49	12	75	38	01	65
39	88	50	13	76	39	02	66
40	889	951	1014	1077	1140	1203	1267
41	90	52	15	78	41	04	68
42	91	53	16	79	42	05	69
43	92	55	17	80	43	07	70
44	93	56	18	81	44	08	72
45	894	957	1019	1082	1145	1209	1273
46	95	58	20	83	46	10	74
47	96	59	21	84	47	11	75
48	98	60	22	85	48	12	76
49	99	61	23	86	49	13	77
50	900	962	1024	1087	1150	1214	1278
51	01	63	25	88	51	15	79
52	02	64	26	89	52	16	80
53	03	65	27	90	54	17	81
54	04	66	29	91	55	18	82
55	905	967	1030	1092	1156	1219	1283
56	06	68	31	93	57	20	84
57	07	69	32	95	58	21	85
58	08	70	33	96	59	22	87
59	09	71	34	97	60	24	88

Degrees of Latitude.

	21	22	23	24	25	26	27
0	1289	1353	1418	1484	1549	1616	1683
1	90	54	19	85	51	17	84
2	91	55	20	86	52	18	85
3	92	56	21	87	53	19	86
4	93	57	22	88	54	20	88
5	1294	1359	1424	1489	1555	1622	1689
6	95	60	25	90	56	23	90
7	96	61	26	91	57	24	91
8	97	62	27	92	58	25	92
9	98	63	28	93	59	26	93
10	99	1364	1429	1495	1561	1627	1694
11	1300	65	30	96	62	28	95
12	02	66	31	97	63	29	96
13	03	67	32	98	64	30	98
14	04	68	33	99	65	32	99
15	1305	1369	1434	1500	1566	1633	1700
16	06	70	36	01	67	34	01
17	07	72	37	02	68	35	02
18	08	73	38	03	69	36	03
19	09	74	39	04	70	37	04
20	1310	1375	1440	1505	1572	1638	1705
21	11	76	41	07	73	39	07
22	12	77	42	08	74	40	08
23	13	78	43	09	75	42	09
24	14	79	44	10	76	43	10
25	1316	1380	1445	1511	1577	1644	1711
26	17	81	47	12	78	45	12
27	18	82	48	13	79	46	13
28	19	83	49	14	80	47	15
29	20	84	50	15	82	48	16

Degrees of Latitude.

M.	21	22	23	24	25	26	27
30	1321	1386	1451	1516	1583	1649	1717
31	22	87	52	18	84	51	18
32	23	88	53	19	85	52	19
33	24	89	54	20	86	53	20
34	25	90	55	21	87	54	21
35	1326	1391	1456	1522	1588	1655	1722
36	27	92	57	23	89	56	24
37	28	93	58	24	90	57	25
38	29	94	60	25	92	58	26
39	30	95	61	26	93	59	27
40	1332	1396	1462	1527	1594	1661	1728
41	33	98	63	29	95	62	29
42	34	99	64	30	96	63	30
43	35	1400	65	31	97	64	31
44	36	01	66	32	98	65	33
45	1337	02	1467	1533	1599	1666	1734
46	38	03	68	34	1600	67	35
47	39	04	69	35	02	68	36
48	40	05	70	36	03	70	37
49	41	06	72	37	04	71	38
50	1342	1407	1473	1538	1605	1672	1739
51	43	08	74	40	06	73	40
52	45	09	75	41	07	74	42
53	46	11	76	42	08	75	43
54	47	12	77	43	09	76	44
55	1348	1413	1478	1544	1610	1677	1745
56	49	14	79	45	12	79	46
57	50	15	80	46	13	80	47
58	51	16	81	47	14	81	48
59	52	17	82	48	15	82	50

Degrees of Latitude.

M	28	29	30	31	32	33	34
0	1751	1819	1888	1958	2028	2099	217[illegible]
1	52	20	89	59	29	2100	[illegible]
2	53	21	90	60	30	01	[illegible]
3	54	22	91	61	31	03	[illegible]
4	55	24	92	62	33	04	[illegible]
5	1756	1825	1894	1963	2034	2105	[illegible]
6	57	26	95	65	35	06	[illegible]
7	59	27	96	66	36	07	[illegible]
8	60	28	97	67	37	09	81
9	61	29	98	68	39	10	82
10	1762	1830	99	1969	2040	2111	2183
11	63	32	1901	70	41	12	84
12	64	33	02	72	42	13	85
13	65	34	03	73	43	14	87
14	66	35	04	74	44	16	88
15	1768	1836	1905	1975	2046	2117	2189
16	69	37	06	76	47	18	90
17	70	38	08	77	48	19	92
18	71	40	09	79	49	21	93
19	72	41	10	80	50	22	94
20	1773	1842	1911	1981	2052	2123	2196
21	74	43	12	82	53	24	97
22	76	44	13	83	54	25	98
23	77	45	14	84	55	27	99
24	78	46	16	86	56	28	2200
25	1779	1848	1917	1987	2057	2129	01
26	80	49	18	88	59	30	02
27	81	50	19	89	60	31	04
28	82	51	20	90	61	33	05
29	[illegible]	52	21	91	62	34	06

Degrees of Latitude.

	28	29	30	31	32	33	34
30	1785	1852	1923	1993	2063	2135	2207
31	86	54	24	94	65	36	09
32	87	56	25	95	66	37	10
33	88	57	26	96	67	39	11
34	89	58	27	97	68	40	12
35	1790	1859	1928	98	2069	2141	2213
36	92	60	30	2000	70	42	15
37	93	61	31	01	72	43	16
38	94	63	32	02	73	45	17
39	95	64	33	03	74	46	18
40	96	1865	1934	2004	2075	2147	2219
41	97	66	35	06	76	48	21
42	98	67	37	07	78	49	22
43	1800	68	38	08	79	51	23
44	01	69	39	09	80	52	24
45	02	1871	1940	2010	2081	2153	2226
46	03	72	41	11	82	54	27
47	04	73	42	13	84	55	28
48	05	74	44	14	85	57	29
49	06	75	45	15	86	58	30
50	1808	1876	1946	2016	2087	2159	2232
51	09	77	47	17	88	60	33
52	10	79	48	18	90	61	35
53	11	80	49	20	91	62	35
54	12	81	51	21	92	64	36
55	1813	1882	1952	2022	2093	2165	2238
56	14	83	53	23	94	66	39
57	16	84	54	24	95	68	40
58	17	86	55	26	97	69	41
59	18	87	56	27	98	70	43

Degrees of Latitude.

M	35	36	37	38	39	40	41
0	2244	2318	2392	2468	2544	2622	2701
1	45	19	93	69	46	24	02
2	46	20	95	70	47	25	04
3	47	21	96	72	48	26	05
4	49	22	97	73	50	27	06
5	2250	2324	98	2474	2551	2629	2708
6	51	25	2400	75	52	30	09
7	52	26	01	77	54	31	11
8	54	27	02	78	55	33	12
9	55	29	03	79	56	34	13
10	2256	2330	2405	2480	2557	2635	2714
11	57	31	06	82	59	37	16
12	58	32	07	83	60	38	17
13	60	34	08	84	61	39	18
14	61	35	10	86	63	41	20
15	2262	2336	2411	2487	2564	2642	2721
16	63	37	12	88	65	43	22
17	65	39	14	89	66	44	24
18	66	40	15	91	68	46	25
19	67	41	16	92	69	47	26
20	2268	2342	2417	2493	2570	2648	2728
21	70	44	19	95	72	50	29
22	71	45	20	96	73	51	30
23	72	46	21	97	74	52	32
24	73	47	22	98	75	54	33
25	2274	2348	2424	2500	2577	2655	2734
26	76	50	25	01	78	56	36
27	77	51	26	02	79	58	37
28	78	52	27	03	81	59	38
29	79	53	29	05	82	60	40

Degrees of Latitude.

M.	35	36	37	38	39	40	41
30	2281	2355	2430	2506	2583	2662	2741
31	82	56	31	07	85	63	42
32	83	57	32	09	86	64	44
33	84	58	34	10	87	66	45
34	85	60	35	11	88	67	46
35	2287	2361	2436	2512	2590	2668	2748
36	88	62	37	14	91	69	49
37	89	63	39	15	92	71	50
38	90	65	40	16	94	72	52
39	92	66	41	18	95	73	53
40	2293	2367	2442	2519	96	2675	2754
41	94	68	44	20	98	76	56
42	95	70	45	21	99	77	57
43	97	71	46	23	2600	79	58
44	98	72	48	24	01	80	60
45	99	2373	2449	2525	03	2681	2761
46	2300	75	50	27	04	83	62
47	01	76	51	28	05	84	64
48	03	77	53	29	07	85	65
49	04	78	54	30	08	87	67
50	2305	2380	2455	2532	2609	2688	2768
51	06	81	56	33	11	89	69
52	08	82	58	34	12	91	71
53	09	83	59	35	13	92	72
54	10	85	60	37	14	93	73
55	2311	2386	2461	2538	2616	2695	2775
56	13	87	63	39	17	96	76
57	14	88	64	41	18	97	77
58	15	90	65	42	20	99	79
59	16	91	67	43	21	2700	80

Degrees of Latitude.

M.	42	43	44	45	46	47	48
0	2781	2863	2945	3030	3115	3202	3291
1	83	64	47	31	17	04	93
2	84	65	48	32	18	05	94
3	85	67	50	34	19	07	96
4	87	68	51	35	21	08	97
5	2788	2870	2952	3037	3122	3210	99
6	89	71	54	38	24	11	3300
7	91	72	55	39	25	13	02
8	92	74	57	41	27	14	03
9	93	75	58	42	28	16	05
10	2795	2876	2959	3044	3130	3217	3306
11	96	78	61	45	31	18	08
12	97	79	62	47	32	20	09
13	99	80	64	48	34	21	11
14	2800	82	65	49	35	23	12
15	02	2883	2966	3051	3137	3224	3314
16	03	85	68	52	38	26	15
17	04	86	69	54	40	27	17
18	06	87	70	55	41	29	18
19	07	89	72	56	43	30	20
20	2808	2890	2973	3058	3144	3232	3321
21	10	91	75	59	45	33	23
22	11	93	76	61	47	35	24
23	12	94	77	62	48	36	26
24	14	96	75	64	50	38	27
25	2815	97	2980	3065	3151	3239	3329
26	16	98	82	66	53	41	30
27	18	2900	83	68	54	42	32
28	19	01	84	69	56	44	33
29	20	02	85	71	57	45	35

Degrees of Latitude.

M.	42	43	44	45	46	47	48
30	2822	2904	2987	3072	3159	3247	3336
31	23	05	89	74	60	48	38
32	25	07	90	75	61	49	39
33	26	08	91	76	63	51	41
34	27	09	93	78	64	52	42
35	2829	2911	2994	3079	3166	3254	3344
36	30	12	96	81	67	55	45
37	31	14	97	82	69	57	47
38	33	15	99	84	70	58	48
39	34	16	3000	85	72	60	50
40	2835	2918	01	3086	3173	3261	3351
41	37	19	03	88	75	63	53
42	38	20	04	89	76	64	54
43	39	22	06	91	77	66	56
44	41	23	07	92	79	67	57
45	2842	2925	3008	3094	3180	3269	3359
46	44	26	10	95	82	70	60
47	45	27	11	96	83	72	62
48	46	29	13	98	85	73	63
49	48	30	14	99	86	75	65
50	2849	2932	3015	3101	3188	3276	3366
51	50	33	17	02	89	78	68
52	51	34	18	04	91	79	70
53	53	36	20	05	92	81	71
54	54	37	21	07	94	82	73
55	2856	2938	3022	3108	3195	3284	3374
56	57	40	24	09	96	85	76
57	59	41	25	11	98	87	77
58	60	43	27	12	99	88	79
59	61	44	28	14	3200	90	80

Degrees of Latitude.

M.	49	50	51	52	53	54	55
0	3382	3474	3568	3665	3763	3864	3968
1	83	76	70	66	65	66	69
2	85	77	72	68	67	67	71
3	86	79	73	70	68	69	73
4	88	80	75	71	70	71	75
5	3389	3482	3576	3673	3772	3873	3976
6	91	83	78	75	73	75	78
7	92	85	82	76	75	76	80
8	94	87	81	78	77	78	82
9	95	88	83	80	78	80	83
10	3397	3490	3584	3681	3780	3881	3985
11	99	91	86	83	82	83	87
12	3400	93	88	84	83	85	89
13	02	94	89	86	85	87	90
14	03	96	91	88	87	88	92
15	05	98	3592	3689	3788	3890	3994
16	06	99	94	91	90	92	96
17	08	3501	96	93	92	93	97
18	09	02	97	94	93	95	99
19	11	04	99	96	95	97	4001
20	3412	05	3600	97	3797	99	03
21	14	07	02	99	98	3900	04
22	15	08	04	3701	3800	02	06
23	17	10	05	02	02	04	08
24	18	12	07	04	04	05	10
25	3420	3513	3608	06	05	3907	4012
26	22	15	10	07	07	09	13
27	23	16	12	09	09	11	15
28	25	18	13	11	10	12	17
29	26	19	15	12	12	14	19

Degrees of Latitude.

M.	49	50	51	52	53	54	55
30	3428	3521	3616	3714	3814	3916	402[illegible]
31	29	23	18	16	15	17	22
32	31	24	20	17	17	19	24
33	32	26	21	19	19	21	26
34	34	27	23	20	20	23	27
35	3435	3529	3624	3722	3822	3924	4029
36	37	30	26	24	24	26	31
37	38	32	28	25	25	28	33
38	40	34	29	27	27	29	3[illegible]
39	42	35	31	29	29	31	3[illegible]
40	3443	3537	3632	3730	3830	3933	4038
41	45	38	34	32	32	35	40
42	46	40	36	34	34	36	42
43	48	42	37	35	36	38	43
44	49	43	39	37	37	40	45
45	3451	3545	3641	3739	3839	3942	4047
46	52	46	42	40	41	43	49
47	54	48	44	42	42	45	50
48	55	49	45	44	44	47	52
49	57	51	47	45	46	49	54
50	3459	3553	3649	3747	3847	3950	4056
51	60	54	50	49	49	52	58
52	62	56	52	50	51	54	59
53	63	57	53	52	52	55	61
54	65	59	54	53	54	57	63
55	3466	3561	3657	3755	3856	3959	4065
56	68	62	58	57	58	61	66
57	69	64	60	58	59	62	68
58	71	65	62	60	61	64	70
59	73	67	63	62	63	66	72

Degrees of Latitude.

M.	56	57	58	59	60	61	62
0	4074	4182	4294	4409	4527	4649	4775
1	75	84	96	11	29	51	77
2	77	86	98	13	31	53	79
3	79	88	4300	15	33	55	81
4	81	90	02	17	35	57	83
5	[illegible]	4192	04	4419	4537	4659	4786
6	84	93	05	21	39	61	88
7	86	95	07	23	41	64	90
8	88	97	09	25	43	66	92
9	90	99	11	26	45	68	94
10	4092	4201	4313	4428	4547	4670	4796
11	94	03	15	30	49	72	98
12	95	04	17	32	51	74	4801
13	97	06	19	34	53	76	03
14	99	08	21	36	55	78	05
15	4101	4210	4323	4438	4557	4680	4807
16	02	12	24	40	59	82	09
17	04	14	26	42	61	84	11
18	06	16	28	44	63	86	13
19	08	17	30	46	65	88	16
20	4110	4219	4332	4448	4567	4691	4818
21	12	21	34	50	69	93	20
22	13	23	36	52	71	95	22
23	15	25	38	54	73	97	24
24	17	27	40	56	76	99	26
25	4119	4229	4342	4458	4578	4701	4829
26	20	30	43	60	80	03	31
27	22	32	45	62	82	05	33
28	24	34	47	64	84	07	35
29	26	36	49	66	86	09	37

Degrees of Latitude.

M.	56	57	58	59	60	61	62
30	4128	4238	4351	4468	4588	4711	4839
31	29	40	53	70	90	14	41
32	31	42	55	72	92	16	44
33	33	43	57	74	94	18	46
34	35	45	59	76	96	20	48
35	4137	4247	4361	4478	98	4722	4850
36	39	49	63	79	4600	24	52
37	40	51	65	81	02	26	55
38	42	53	66	83	04	28	57
39	44	55	68	85	06	30	59
40	4146	4257	4370	4487	4608	4733	4861
41	48	58	72	89	10	35	63
42	49	60	74	91	12	37	65
43	50	62	76	93	14	39	68
44	53	64	78	95	16	41	70
45	4155	4266	4380	97	4618	4743	4872
46	57	68	82	99	20	45	74
47	59	70	84	4501	22	47	76
48	60	72	86	03	24	49	79
49	62	73	88	05	26	52	81
50	4164	4275	4390	07	4629	4754	4883
51	66	77	92	09	31	56	85
52	68	79	93	11	33	57	87
53	70	81	95	13	35	60	89
54	71	83	97	15	37	62	91
55	4173	4285	99	4517	4639	4764	4894
56	75	87	4401	19	41	60	96
57	77	88	03	21	43	68	98
58	79	90	05	23	45	71	4900
59	81	92	07	25	47	73	03

Degrees of Latitude.

M.	63	64	65	66	67	68	69
0	4905	5039	5179	5324	5474	5631	5795
1	07	42	81	26	77	34	98
2	09	44	84	29	79	37	5800
3	11	46	86	31	82	39	03
4	14	49	88	33	84	42	06
5	4916	5051	5191	5336	5487	5644	5809
6	18	53	93	38	89	47	12
7	20	55	95	41	92	50	14
8	23	58	98	43	95	52	17
9	25	60	5200	46	97	55	20
10	4927	5062	03	5348	5500	5658	5823
11	29	65	05	51	02	60	26
12	31	67	07	53	05	63	28
13	34	69	.10	56	08	66	31
14	36	71	12	58	10	69	34
15	4938	5074	5214	5361	5513	5671	5837
16	40	76	17	63	15	74	40
17	42	78	19	66	18	77	43
18	45	81	22	68	20	79	45
19	47	83	24	71	23	82	48
20	4949	5085	5226	5373	5526	5685	5851
21	51	88	29	76	28	87	54
22	54	90	31	78	31	90	57
23	56	92	34	81	33	93	60
24	58	95	36	83	36	96	62
25	4960	97	5238	5386	5539	5698	5865
26	63	99	41	88	41	5701	68
27	65	5101	43	91	44	04	71
28	67	04	46	93	46	06	74
29	69	06	48	96	49	09	77

Degrees of Latitude.

M.	63	64	65	66	67	68	69
30	4972	5108	5250	5398	5552	5712	5879
31	74	11	53	5401	54	15	82
32	76	13	55	03	57	17	85
33	78	15	58	06	60	20	88
34	81	18	60	08	62	23	91
35	4983	5120	5263	5411	5565	5726	94
36	85	22	65	13	67	28	97
37	87	25	67	16	70	31	5900
38	90	27	70	18	73	34	02
39	92	29	72	21	75	37	05
40	4994	5132	5275	5423	5578	5739	5908
41	96	34	77	26	81	42	11
42	99	36	80	28	83	45	14
43	5001	39	82	31	86	48	17
44	03	41	84	33	88	50	20
45	05	5143	5287	5436	5591	5753	5923
46	08	46	89	38	94	56	25
47	10	48	92	41	96	59	28
48	12	51	94	43	99	61	31
49	14	53	97	46	5602	64	34
50	5017	5155	99	5449	04	5767	5937
51	19	58	5301	51	07	70	40
52	21	60	04	54	10	72	43
53	23	62	06	56	12	75	46
54	26	65	09	59	15	78	49
55	5028	5167	5311	5461	5618	5781	5952
56	30	69	14	64	20	84	55
57	33	72	16	66	23	86	57
58	35	74	19	69	26	89	60
59	37	76	21	72	28	92	63

Degrees of Latitude.

M.	70	71	72	73	74	75	67
0	5966	6146	6335	6534	6746	6971	7211
1	69	49	38	38	50	75	15
2	72	52	42	42	54	79	19
3	75	55	45	45	57	83	23
4	78	58	48	49	61	87	27
5	5981	6161	6351	6552	6765	6990	7232
6	84	65	55	57	68	94	36
7	87	68	58	59	72	98	40
8	91	71	61	62	75	7002	44
9	93	74	64	66	79	06	48
10	96	6178	6367	6569	6782	10	7253
11	98	80	71	73	86	14	57
12	6001	83	74	76	90	18	61
13	04	86	78	80	94	22	65
14	07	89	81	83	98	26	69
15	10	6192	6384	6587	6801	7030	7274
16	13	96	87	90	05	33	78
17	16	99	91	94	09	37	82
18	19	6202	94	97	12	41	86
19	22	05	97	6601	16	45	90
20	6025	08	6304	04	6820	7049	7295
21	28	11	05	08	23	53	99
22	31	14	07	11	27	57	7303
23	34	17	10	14	31	61	07
24	35	21	14	18	35	65	12
25	6040	6224	6417	6621	6838	7069	7316
26	43	27	20	25	42	73	20
27	46	30	24	29	46	77	24
28	49	33	27	32	49	81	29
29	52	36	30	36	53	85	33

Degrees of Latitude.

M.	70	71	72	73	74	75	76
30	6055	6239	6434	6639	6857	7089	7337
31	58	43	37	43	61	93	42
32	61	46	40	46	64	97	46
33	64	49	44	50	68	7101	50
34	67	52	47	53	72	05	54
35	6070	6255	6450	6657	6876	09	7359
36	73	58	54	60	79	13	63
37	76	62	57	64	83	17	67
38	79	65	60	67	87	21	72
39	82	68	64	71	91	25	76
40	6085	6271	6467	6674	6895	7129	7380
41	88	74	70	78	98	33	85
42	91	77	74	82	6902	37	89
43	94	81	77	85	06	41	93
44	97	84	81	89	10	45	98
45	6100	6287	6484	6692	6914	7149	7402
46	03	90	87	96	17	53	06
47	06	93	91	99	21	58	11
48	09	97	94	6703	25	62	15
49	12	6300	97	07	29	66	20
50	6115	03	6501	6710	6933	7170	7424
51	18	06	04	14	36	74	28
52	22	09	08	17	40	78	33
53	25	13	11	21	44	82	37
54	28	16	14	25	48	86	42
55	6131	6319	6518	6728	6952	7190	7446
56	34	22	21	32	56	94	50
57	37	26	25	35	59	99	55
58	40	29	28	39	63	7203	59
59	43	32	31	43	67	07	64

Degrees of Latitude.

M.	77	78	79	80	81	82	83
0	7468	7746	8047	8377	8741	9148	[illegible]
1	73	51	52	83	47	55	[illegible]
2	77	55	58	88	54	62	[illegible]
3	82	60	63	94	60	69	[illegible]
4	86	65	68	8400	67	77	[illegible]
5	7491	7770	8073	06	8773	9184	[illegible]
6	95	75	79	12	80	91	[illegible]
7	99	80	84	17	86	99	[illegible]
8	7504	84	89	23	93	9206	[illegible]
9	08	89	95	29	99	13	[illegible]
10	13	94	8100	8435	8806	9220	[illegible]
11	17	99	05	41	12	28	[illegible]
12	22	7804	11	47	19	35	[illegible]
13	27	09	16	53	25	43	[illegible]
14	31	14	21	58	32	51	[illegible]
15	7536	19	8127	8464	8838	9257	[illegible]
16	40	24	32	70	45	65	[illegible]
17	45	29	37	76	52	72	[illegible]
18	49	33	43	82	58	80	[illegible]
19	54	38	48	88	65	87	[illegible]
20	7558	7843	8154	94	8871	95	[illegible]
21	63	48	59	8500	78	9302	[illegible]
22	67	53	64	06	85	10	[illegible]
23	72	58	70	12	91	17	[illegible]
24	77	63	75	18	98	25	[illegible]
25	7581	7868	8181	8524	8905	9333	[illegible]
26	86	73	86	30	11	40	[illegible]
27	90	78	92	36	18	48	[illegible]
28	95	83	97	42	25	55	[illegible]
25	7600	88	8203	48	32	63	[illegible]

Degrees of Latitude.

M	77	78	79	80	81	82	83
30	7604	7893	8208	8554	8938	9371	9864
31	09	98	14	60	45	78	73
32	13	7903	19	66	52	86	82
33	18	08	25	72	59	94	91
34	23	13	30	79	66	9401	9900
35	7627	7918	8236	8585	8972	09	09
36	32	23	41	91	79	17	18
37	37	28	47	97	86	25	27
38	41	34	52	8603	93	32	36
39	46	39	58	09	9000	40	45
40	7651	7944	8263	8615	07	9448	9954
41	55	49	69	22	14	56	63
42	60	54	75	28	21	64	72
43	65	59	80	34	28	72	81
44	70	64	86	40	35	80	90
45	7674	7969	8291	8646	9042	88	10000
46	79	74	97	53	49	96	09
47	84	80	8303	59	56	9503	18
48	88	85	08	65	63	11	27
49	93	90	14	71	70	19	37
50	98	95	8320	8678	9077	9527	10046
51	7703	8000	25	84	84	36	55
52	07	05	31	90	91	44	65
53	12	11	37	97	98	52	74
54	17	16	42	8703	9105	60	8[illegible]
55	7722	8021	8348	8709	12	9568	1009[illegible]
56	27	26	54	16	19	74	10102
57	31	31	60	22	26	83	12
58	36	37	65	28	33	92	2[illegible]
59	41	42	71	35	41	9600	31

Degrees of Latitude.

M.	84	85	86	87	88	89
00	10140	10769	11538	12520	13920	[illegible]
1	50	81	53	40	48	[illegible]
2	60	92	67	59	78	[illegible]
3	69	10804	82	78	14007	[illegible]
4	79	15	96	98	37	[illegible]
5	89	27	11611	12618	66	[illegible]
6	98	39	26	37	97	[illegible]
7	10208	51	41	57	14127	[illegible]
8	18	62	55	77	58	[illegible]
9	28	74	70	97	89	[illegible]
10	10238	86	85	12718	14220	[illegible]
11	48	99	11700	38	52	[illegible]
12	57	10910	15	58	83	[illegible]
13	67	22	30	79	14316	[illegible]
14	77	34	46	12800	48	[illegible]
15	87	46	61	21	81	[illegible]
16	97	58	78	42	14414	[illegible]
17	10307	70	92	63	47	[illegible]
18	17	82	11807	84	81	[illegible]
19	27	95	23	12905	14515	[illegible]
20	10338	11007	38	27	49	[illegible]
21	48	19	54	48	84	[illegible]
22	58	32	70	70	14619	[illegible]
23	68	44	86	92	55	[illegible]
24	78	57	11902	13014	90	[illegible]
25	89	69	18	36	14727	[illegible]
26	99	82	34	59	63	[illegible]
27	10409	94	50	81	14800	[illegible]
28	20	11107	66	13104	37	[illegible]
29	30	20	82	26	75	[illegible]

Degrees of Latitude.

M.	84	85	86	87	88	89
30	10440	11138	11999	13150	14914	18729
31	51	45	12015	73	52	18848
32	62	58	32	96	91	18970
33	72	71	48	13219	15031	19098
34	83	84	65	43	71	19230
35	93	97	82	66	15111	19368
36	10504	11210	99	91	52	19511
37	14	23	12116	13315	94	19660
38	25	36	33	39	15236	19816
39	36	49	50	63	78	19980
40	10547	62	67	88	15321	20152
41	57	76	84	13412	64	20333
42	68	89	12202	37	15408	20524
43	79	11303	19	62	53	20726
44	90	16	37	88	98	20941
45	10601	29	54	13513	15544	21170
46	12	43	72	39	91	21460
47	23	57	90	65	15638	21680
48	34	70	12308	91	86	21967
49	45	84	26	13617	15734	22279
50	10656	98	44	43	83	22623
51	67	11412	62	70	15833	23005
52	78	25	81	97	84	23435
53	90	39	99	13725	15935	23926
54	10701	53	12408	51	87	24499
55	12	67	26	79	16040	25186
56	23	81	45	13807	93	26046
57	35	96	64	34	16148	27192
58	46	11510	83	63	16203	28911
59	58	24	12502	91	60	32348

The Construction of the True Sea-Chart, by the Table of the Meridional Parts.

FIG. 60.

LEt it be required to make a Chart from the Latitude of 48° 00′ to the Latitude of 5[illegible] containing eight degrees of Longitude.

Draw the line AB, which divide into eight equal parts, so shall each part represent a degree of Longitude: Upon A, draw AC perpendicular to AB; and from B, draw BD parallel to AC: also from each of the eight equal divisions in the line AB draw Parallel lines, as in the figure; so shall these lines represent Meridians.

To graduate the Meridian AC or BD, find in the foregoing Table, the Meridional parts for 48° of Latitude, *viz.* 3291. Also find the respond-ing parts of the Latitude of 49° 00′, *viz.* 33[illegible] subtract the lesser of those two numbers from the greater, and the remainer will be 91.

This done, you must divide each of the eight equal parts in the line AB into 10 other equal parts, so shall each of these small Divisions contain six minutes. Lastly, from this Scale AB take 91 parts and set the same from 48 to 49 upon the Meridian line AC, and from 49 draw the Parallel from that Latitude. Again, from the Meridional parts answering to 50 deg. (the next degree of Latitude) *viz.* 3474, take the Meridional parts for 49° of Latitude, *viz.* 33[illegible]

remainer is 92, which taken from the line must be applyed from 49 to 50 degrees, draw the parallel of 50 degrees as in the re, and so proceed till you come to 54 degrees of Latitude.

Lastly, That the distance of places may be readily found by this Chart, you must draw line EF, which is divided into 5 degrees 24 nutes: each degree in this line being equal two Degrees in the Line AB, and divided into ten equal parts, as were the other. This so graduated is called the Auxiliary line, whose use shall be declared in its due place.

Having thus far explained the Construction such Geographical Charts, (both General Particular, Circular, and Rectilinear) as are necessary for understanding the true Idea Navigation, I proceed to their use; omitting Construction of those, whose Lineaments depend upon Segments of Ellipses, and Hyperbolas, because it is impossible to understand the nature of these lines without some previous Account of Conic Sections.

CHAP. IX.

Of the Mariner's Compass, and of Nature of Rumb-lines. Fig. Plate 2d.

WHen mankind first became sensible of possibility of travelling by Sea, as upon the *Terra Firma*, they began to con the situation of places. To which end they vided the Horizon into four equal parts, East, South, West and North, being direct these 4 Coasts by the motion of the Sun, his rising, they found the East point; Southing the South and North points, and Setting, the West point.

But this advantage was of no use to them the night time, which obliged them more rowly to consider the motion of the fixed S *viz.* the Pleiades, and the last in the Tayl the little Bear: That the Pleiades was used the Ancients for this purpose, seems to be plyed from the Etymologie of the word; in the Greek, πλεῖν (from whence some the word Pleiades took it's name) signifies Sayle, and because of it's position, which is far from the Equator, whereby they could

the Night discover the East by it's rising; the South and North, by it's Culmination; and the West points of the Horizon by it's setting.

The last Star in the little Bear's tayle has been for many Ages so near the North pole of the World, that the Circle it describes about it is almost insensible; and therefore as Seamen used it before the discovery of the Magnet, the difference in being directed by this Star, or by the Pole it self was inconsiderable.

This was the practice of Seamen in the Infancy of Navigation, and when intervening Clouds did not deprive them of these helps, were the best guides they had to direct them in their Course: but in thick and cloudy weather, they were at a loss, not knowing which way to steer, till the use of the Magnet came to be known: and then they took leave of their old Friends, the Stars, having no further occasion for their help.

Also those who inhabited the Southern Temperate Zone, or any where between the Equator and the South Pole, were totally deprived of the Benefit of being directed by the Pole Star, because there is no remarkable Star posited so near to the South Pole, as that of the little Bear, is to the North.

But upon the Invention of the Compass, they found a certain Directory both by day and night: this Compass they divided into 32 equal parts, whose Names in these five several Languages are as follow.

English

English	Latin	Greek	Italian	Spanish
North	Septentrio	Ἀπαρκτίας	Tramantana	Norte
N by E	Hypaquilo	Ὑπερβορέας	4 di Tramontana Graco	Norte 4 a Nordest
N N E	Aquilo	Βορέας	Tramontana Graco	Nord Nord' este
N E by N	Mesaquilo	Μεσοβορέας	4 di Tramontano Graco	Nord' este 4 a Norte
N E	Borrapeliotes	Βορραπηλιώτης	Graco	Nord' este
N E by E	Hypocacias	Ὑποκαικίας	4 di Graco Levante	Nord 4 al Este
E N E	Casius	Καικίας	Levante Graco	Les Nord a' Este
E by N	Mesocacias	Μεσοκαικίας	4 di Levante Graco	Les 4 a Nordeste
East	Subsolanus	Ἀπηλιώτης	Levante	L'este
E by S	Ypeurus	Ὑπεῦρος	4 di Levante Sirocco	L'este 4 a Sueste
E S E	Eurus	Εὖρος	Levante Sirocco	L'e Sueste
S E by E	Meseurus	Μεσεῦρος	4 di Levante Sirocco	Sueste 4 al' Este
S E	Notapeliotes	Νοταπηλιώτης	Sirocco	Sueste
S E by S	Hypophœnix	Ὑποφοινικίας	4 di Sirocco Ostro	Sueste 4 al' Sur
S S E	Phœnix	Φοινικίας	Ostro Sirocco	Sur Sueste
S by E	Mesophœnix	Μεσοφοινικίας	4 di Ostro Sirocco	Sur 4 a Sueste

English

English	Latin	Greek	Italian	Spanish
South	Notus	Νότος	Ostro	Sur
S by W	Mesolibanotus	Μεσολιβόνοτος	4 di Ostro Garbino	Sur 4 al Sudeste
S S W	Libanotus	Λιβόνοτος	Ostro Garbino	Sud Sudueste
S W by S	Hypolibanotus	Ὑπολιβόνοτος	4 di Garbino Ostro	Sud Vest 4 al' Sud
S W	Notalybicus	Νοτολίψ	Garbino o Libeccio	Sud Vest
SW by W	Mesafricus	Μεσολίψ	4 di Garbino Pouente	Sud Vest 4 al Oeste
W S W	Africus	Λίψ	Ponente Garbino	Oeste Sud Oeste
W by S	Hypafricus	Ὑπολίψ	4 di Ponente Garbino	Oest 4 al Sudueste
West	Zephyrus	Ζέφυρος	Ponente	Oest
W by N	Mesocorus	Μεσαργέστης	4 di Ponente Maestro	Oest 4 al Nord Oest
W N W	Corus	Ἀργέστης καυρος	Ponente Maestro	Oest Nord Oeste
N W by W	Hypocorus	Ὑπαργέστης	4 di Maestro Ponente	Nord Oest 4 al Nort
N W	Borrolybicus	Βορρολίψ	Maestro	Nord Oeste
N W by N	Hypocircius	Ὑποθρασκίας	4 di Maestro Tramont	Nord Oeste 4 a Nor
N N W	Circius	Θρασκίας	Tramontana Maestro	Nor Nor Oeste
[illegible]	[illegible]	[illegible]	4 di Tramont. Maestro	Nor 4 a Noroeste

By

By the Sea Compass we learn to find the true Course between any two Places; a secret unknown till the discovery of this useful Instrument: for how could the Seamen of old, fluctuating upon the surface of the Sea, where they could see nothing, *nisi Pontus & Æther*; direct a Ship between any two places, not knowing the Rhumb or Course from the one to the other? The want of which knowledge did much retard the improvement of Navigation in those times. And this was the reason why the new world of *America* lay so long undiscovered.

The Sea Compass (by which we find out the Course from one place to another) is nothing else than a Box having a Brass Pin in the middle, upon which a round piece of stiff Paper (furnished with a hollow Center, called the Cap, and a piece of Steel or Iron Wyer) always moves. This Wyer being commonly bent in form of a Rhombus, one of its angles lying under the North point or *Flower de luce*, the other opposite angle lying under the South Point thereof. This Instrument being thus far prepared, they take the Chard or stiff Paper, the Wyer being first fastened to it, and rub the acute angle of the Rhombus which lies under the No. Point, upon the South Pole of the Magnet, and the opposite acute angle of the Rombus which lies under the South Point of the Chard, they rub upon the North Pole of the same Magnet, and then the Chard being placed with its Cap upon the Pin, does (by an unaccountable property of the Stone) apply it self to a true Meridian, or near to that Position. The virtue of this Stone or Magnet

agnet is such, that if the Poles thereof be first
und, and the Magnet it self be appended to a
ring, so, that it may move freely (without
ny impediment) it will never cease to move,
ll its Poles stand exactly North or South. And
his is the Construction of that Instrument called
he Sea-Compass, by whose help we can direct a
hip through the untrac'd surface of the Sea,
etween any two assigned Places.

The Compass thus prepared and touched, does
n some places apply it self to a true Meridian,
n other places, it does not shew the true North
nd South Points of the Horizon, but deviates
rom them, and this deviation is called the decli-
ation thereof, or variation.

Thus at the Azores, the Compass had no vari-
tion, but in several places which lie under that
Meridian, there has been found a variation. In
laces distant from the Azores Eastward, almost
o the Cape of Good Hope, the Compass de-
clines from the North Eastward, and the Decli-
nation thereof is near equal, in all places between
the Azores and Cape *Agullas*; it continues to
decline more and more till you come about 70
degrees further than the Meridian of *Tristan*,
where the Declination is about 18°. from thence
it decreaseth till you come to the Meridian of
Agullas.

Nor has one and the same City the same De-
clination at all times, for here at *London* 1580 the
Declination was 11°. 15'. and in the Year 1622
at the same place it was found to be 6°. 13'. in
the year 1634, it was 4°. 06'. The Reason of
which Phænomenon may be this. The Globe of
Earth

Earth and Sea is of an unequal Temper, ha-
ing more of Water than of Earth in some pl-
and of Earth more or less Magnetical in o-
therefore it must needs be here and then
side towards the East and West.

And because the Compass is liable to v-
on from the true North and South Points
Horizon; and having a variation, is the
unfit to direct a Ship in her true Course,
we will here shew the way how to find the q-
ty of the variation of the Compass.

To find the variation of the Compass.

THe variation of the Compass is usually f-
by the Sun's Amplitude at his Ri-
Setting, but this way is attended with two in-
veniences.

1. The Latitude of the Ship must be e-
known at the time of Sun Rising or Setting, w-
is somewhat too difficult for our ordinary
men, unless they be well grounded in the so-
on of Spherical Triangles.

2. That the refraction of the Sun m-
him appear to be in the Horizon, whe-
is really about 34 minutes below it. Ther-
I shall substitute another way to perf-
the same; which is less difficult, and m-
certain: In order to which observe these follo-
ing Rules.

1. Obse-

1. Obſerve the Sun's Altitude, and point of the Compaſs he is upon at that moment of time, viz. about 7, 8, or 9 a Clock in the morning.

2. Obſerve the point of the Compaſs the Sun is upon, when he has the ſame Altitude in the Afternoon, as he had in the morning, which will happen about 3, 4, or 5 a Clock in the Afternoon, and from theſe two obſervations may the variation be found.

For if theſe points of the Compaſs be equally diſtant from the North or South points of the Compaſs, then there is no variation.

But if the point in the Forenoon, be further diſtant from the Meridian line of the Compaſs, than the point in the Afternoon, then is the variation weſterly.

Laſtly, If the point in the Forenoon be leſs diſtant from the Meridian line of the Compaſs, than the point in the Afternoon, then is the variation Eaſtward.

The quantity of the variation is thus found, take the intercepted Arches between the North point of the Compaſs, and theſe two points, the one in the Forenoon, and the other in the Afternoon found by Obſervation, the leſſer of theſe two Arches being ſubtracted from the greater, half of the remainer is the variation required.

To

To find what angle each point of the Compass [makes] with the Meridian.

Divide 360°. the number of Degrees in the circumference of any Circle by 32 the number of Points in the Compass, the Quotient is 11°, 1[…] ½ which is 11°. 15', and from hence was the following Table computed, which shews how many Deg. and Minutes answer to 1 or ½ or ¼ point of the Compass.

To

	North	South	D.	M.	South	North	
			2.	48			
			5.	37			
			8.	25			
1	N B E	SBE	11.	15	BW	NBW	1
			14.	04			
			16.	53			
			19.	41			
2	N NE	S S E	22.	30	SSW	NNW	2
			25.	19			
			28.	08			
			30.	56			
3	NEBN	SEBS	33.	45	SWBS	NWBN	3
			36.	34			
			39.	23			
			42.	11			
4	N E	SSE	45.	00	SW	NW	4
			47.	49			
			50.	37			
			53.	26			
5	NEBE	SEBE	56.	15	SWBW	NWBW	5
			59.	04			
			61.	52			
			64.	41			
6	ENE	ESE	67.	30	WSW	WNW	6
			70.	19			
			73.	07			
			75.	56			
7	EBN	EBS	78.	45	WBS	WBN	7
			81.	34			
			84.	22			
			87.	11			
8	East	West	00.	00	West	[illegible]	8

M

Of

Of the Nature of Rhomb-Lines.

When the Ship Sails upon the Meridian, or upon any Parallel, it is nothing difficult to determine her way. But when the Ship Sails upon any other point of the Compass, this difficulty is greater than every man imagins; because she alters both her Latitude and Longitude. This Difficulty is so much the greater, by how much the Voyage is more distant from the Æquinoctial towards either Pole: and by how much the Rhumb or point of the Compass she Sails upon is more remote from the Meridian.

For near the Equinoctial, where the Meridians are almost parallel; and in those Rhumbs which are near the Meridian, where the Longitude is but little alter'd, the Errour is insensible.

In Sailing upon any of these Oblique Rhumbs, the Ship is so directed by the Compass, and guided by the Helme, that the line she Sails upon does every where keep the same Angle with the Meridian according to the distance of the Rhumb from the North or South line. And because the Compass is as it were a moveable Horizon, and the lines of direction thereupon are the intersections of Azimuths with the same Horizontal plain, dividing it into so many parts which are called Rhumbs: it comes to pass that in such Oblique Sailing towards the elevated Pole, the place whereunto the the Compass leads is ever more between the Parallel of that Place where you are, and the Pole. Wherefore the line of the Ship's Oblique Course is an Helix or Spiral line

, approaching nearer and nearer to the Pole, never falling into it. Thus in Fig. 59. let Present but the Pole of the World, and all the Contric Circles to be parallels of Latitude descri- at equal distance one from the other, and let streight lines PAC. PEB. PID. POF. PVG cut- these Parallels in the points C. B. D. F. G. H Meridians: and let all the Segments CA. BE. OF. VG be equal in length, tho' the Angles A. BPD, &c. be unequal. Then let us suppose the Ship to Sail directly NE. she shall there- describe the arching line CBDFGH. this line continually approach nearer and nearer to Pole, but can never fall into the Pole, because still keepeth the same distance upon the Com- between the Meridian and the Parallel in ich it is, and maketh with the Meridian, an gle of 45°.

These Spirals (as the learned Dr. *Oughtred* ls you) ought to consist of the most minute indivisible parts, for if they be any whit great, account of the Ship's motion will be confound- ; and carry'd down from the true place whi- the Ship is gone, towards the Equinoctial: ither can you return by the Rhumb you came. r imagine in Fig. 59. two Meridians PAC. K. and that AB and CK are like Segments of o Parallels; so ABCK shall be a kind of a ght-angled Spherical Quadrangle, in which there be drawn the Diagonal CB. upon which Ship is supposed to have moved from C to B. may easily be demonstrated that the angle BL is greater than the angle ACB. this sheweth at you are fallen from your Rhumb into ano-

ther point, and had need to bear up the Ship again into the Rhumb BD, making with the Meridian an angle PBD equal to that other A. Again, the Diagonal arch CB cutteth the Quadrangle into two Triangles unequal one to the other; for tho' in both the sides AC. BK be equal, and the side CB be common to them both, yet the Bases A B and CK, and likewise the angles are unequal, yea tho the distance of the Parallels be but one Scruple of a Degree. But the less you take the distance of these Parallels, that inequality will also be the less. So that if by any artifice it may be brought about that the side AC be not one Minute of a degree, which in the Surface of the Earth is 1, 159. English miles, but the 100000th. part thereof which is less than one Inch, there may be Tables calculated to a Radius of 10000000 which shall reduce these small Spherical Triangles into right angled Spherical Triangles, whereby the Spiral line of the Ship's Course may be recall'd to precise exactness.

Thus having given you a transient account of the Compass, it's variation, and the nature of Oblique Rhumb-lines, I proceed to several useful Geographical Propositions before I enter upon the use of the Charts, or the Art of Navigation.

CHA

CHAP. X.

find the distance of Places when hey lye under the same Meridian, or in the same Parallel.

PROB. 1. Fig. 58.

TO find the Semidiameter of any Parallel, either in Sexagenary or English Miles.

Seeing that every degree is usually divided in- 60 equal parts, commonly called Miles, these les we may call Sexagenary Miles; each of ich exceeds an English Mile, as I noted before, refore the Semidiameter of the Equinoctial ng 60° multiply that by 60 the Sexagenary les in a degree, the product 3600 shall be the nidiameter of the Equator in Sexagenary les.

But if you desire the Semidiameter of the uator in English miles, then because 69. 548 glish make a degree, therefore multiply 69. 8 by 60, the Product 4172.88 shews the Eeglish les contained in the Semidiameter of the E- ator, which being known if it be required to find

find the Semidiametar of any other Parallel, of 30 degrees in Sexagenary miles, say,

As Radius ÆC sine of 90°. 00' —— 1000000
Is to Semidiameter ÆC 3600 ——— 3556
So is the Co-Sine of 30°. 00' ——— 99375

to the numb. of Sexa. miles in that Pa. 3128. 3493

Again to find the same in English miles,

As Radius ÆC Sine of 90°. 00' — 1000000
Is to Semi. of the Equa. ÆC 4172. 88 — 3620
So is the Co-Sine of 30°. 00' *viz.* AD — 99375
to the num. of Eng. miles in that Pa. 3613. 3557

PROB. 2. Fig. 58.

To find how many Miles (both Sexagenary and English) make a degree of Longitude in any Parallel.

In the Latitude of 30°. 00'. I demand how many Sexagenary, and also English Miles, make a degree of Longitude, then because 60 Sexagenary miles make a degree of Longitude at the Equator, and also 69. 548 English miles make a degree of Longitude at the same, therefore for Sexagenary miles.

As the Radius Sine of 90°. 00 ÆC — 1000000
Is to one deg. at the Eq. *viz.* ÆC. 60 miles 17781
So is the Co-Sine of the gi. La. AD. 30. 00 — 99375

to the num. of miles in a deg. of that Parallel, *viz.* AD 51. 96 ——— } 17156

To find the same in English miles.

s Radius Sine of 90°. 00′ viz. ÆC. 10000000
to 69.548 miles in the Equator EC — 1841609
is Co-Sine of the gi.La. AD 30°. 00′ - 9937530

the num.of En. miles required 60.22 -- 1779139

PROB. 3. Fig. 58.

To find the distance of Places posited under the same Meridian.

Two Places cannot be further distant than 180°. or 10800 Sexagenary miles — or lastly 12518. 64 English miles.

CASE 1.

1. If the two Places be posited in the same Quadrant of the same Meridian.

Subtract the Latitude of the lesser, from the Latitude of the greater, the remainer shall be the difference of Latitude in Degrees and minutes, which reduced into Miles gives the distance required — Exam.

Let there be two Places, the one at H, the other at I both in the same Quadrant of the same Meridian, that at H in the Latitude of 40°. 00′ N°. and the other at I in the Latitude of 50°. 00′. both under the same Meridian ANP. RSP. from

	ÆI	50°. 00′.	10
Subtract	ÆH	40. 00	60
Remains	HI	--10. 00	600 Sexagenary mi
			69. 548
			10
			695.480 Eng.mi

CASE 2.

If the two Places propounded be indifferent Quadra of the same Meridian, viz. *the one in No the other in South Latitude, to find their dista asunder.*

Let the one lye in 40°. 00′ North Latitude, t other in 30°. South Latitude add these two numb together, and their Sum shall be the differen of Latitude or nearest distance in degrees a minutes, which reduce as afore.

	40
	30
diff. Lati. D. M.	70
	60
distance in Sexagen.	4200 miles.

CASE

CASE 3.

If the two places lye under the same Meridian, the first on this side the Pole; the second on the other side thereof, the sum of the Complement of these two Latitudes shall be their difference of Latitude, or nearest distance in degree and minute.

EXAMPLE.

Let one Place lye at K on this side the Pole in the North Latitude of 59°. 40′. and let the other Place be I on the other side of the Pole, *viz.* in the North Latitude of 82°. 00′ I demand their distance they being both under one Meridian.

The Complement of QL 82°. 00′ is NPL 8°. 00′, the Complement of ÆK 59°. 40′ is KNP 30°. 20′. these two Complements added together make 38°. 20′ for KL the nearest distance in degrees and minutes.

	38°. 20
	60
Distance in Sexagenary miles	2300

CASE 4.

If two places both under one Meridian be posited in different Quadrants of the same Meridian, these Quadrants not being contiguous, subtract the lesser Latitude from the greater, and that

that remainer from a Semicircle, so shall you have their nearest distance required.

EXAMPLE.

Let one place be K in the North Latitude of 59°. 40′ the other be M in the South Latitude of 30°. 00′. to find their nearest distance in Sexagenary miles.

59°. 40′	distance in D. M. 150°. 20′
30. 00	60
29. 40	distance in Sexag. miles. 9020
180. 00	
150. 20	

PROB. 4. Fig. 58.

If two Places lye under the Equator, and the Longitudes of these two Places be known, the difference of Longitude between them is their nearest distance in degrees and minutes; but if this difference of Longitude exceed 180°. 00′. Subtract it from 360°. 00′ and the remainer shall be the distance required in degrees and minutes.

PROB.

PROB. 5. Fig. 58.

Having the difference of Longitude between two Places lying both in one Parallel, to find their nearest distance in Sexagenary miles.

By Prob. 2. of this Chap. find the number of miles in the Equator which make a degree of Longitude in that Parallel: then multiply the difference of Longitude between these two Places by the Equatorial miles in that Parallel, the product shall be the nearest distance required.

EXAMPLE.

Let the two places be both in the Parallel of 50. and let their diff. Longitude be 12°. then by Problem 2. of this Chap. it appears that 38. 57 Equatorical or Sexagenary miles make a degree of Longitude in that Latitude, therefore

```
 38. 57
     12
 ------
   7714
  3857
 ------
```

Distance required 462. 84 in Sexagenary miles.

The distance of any two places not posited as in these Examples, shall be discoursed of at large in the ensuing Chapter

CHAP.

CHAP. XI.

The use of the Plain Sea Chart.

PROP. 1 Fig. 33.

The Latitude and Longitude of two Places given, to find their bearing and distance.

LET one place be A in the Latitude of 48°. 00′ N°. and Longitude of 20°. 00′ let the other place be B in the North Latitude of 50°. 00′ and Longitude of 22°. 00′.

Draw the line AB, which ſhall repreſent their neareſt diſtance; then upon the line AF meaſure the diſtance AB, and you will find it to reach to D. ſo ſhall AD 2°. 48′. or 56 Leagues be the meaſure of AB, the diſtance required.

Alſo the line AB cuts the Quadrant in 4, which ſhews that the Courſe from A to B is 4 points from the North towards the Eaſt, that is NE.

Note AC is called the diff. of Latitude, and CB the difference of Longitude between theſe two Places.

PROP.

PROP. 2. Fig. 33.

The Courſe and Diſtance, between two Places, with the Latitude and Longitude of one of them given to find the Latitude and Longitude of the other place.

Let one place be A in the N° Latitude of 48°. 00′ and Longitude of 20°. 00′. and let the Courſe given be NE, the diſtance of the two places upon the Courſe be 2°. 48′ or 56 Leagues.

Draw the NE line AB, and from the line AF take 2°. 48′, *viz.* AD, which ſet from A to B, then from B draw the line CB, parallel to AF, ſo ſhall B be the ſecond place required, which by the Chart is found to lie in the N°. Latitude of 50°. 00′. and Longitude of 22°. 00′.

PROP. 3. Fig. 33.

Having the Latitude and Longitude of one Place, with the Latitude and bearing of another Place, to find the Longitude and diſtance of this ſecond Place.

Let one place be A in the N°. Latitude of 48°. and Longitude of 20°. 00′ let the other place lie in the N°. Latitude of 50°. 00′. the Courſe between theſe two being NE.

From C a point in the North Latitude of 50°. 00′. draw CB, parallel to AF, then from A draw the NE line A 4 B, to cut the Parallel of 50°. 00′ in B. So ſhall B be the ſecond place required; whoſe diſtance meaſured as in Prop. 1. of this Chap. is 2°. 48′. or 56 Leagues, and whoſe Longitude

Longitude (by the Chart) appears to
42°. 00′.

By this Prop. we may easily find how
miles or leagues a Ship must Sail upon any poin
the Compass to raise or depress the Pole one De-
gree.

Thus let AE represent one Degree of Lati
from A, through each point in the Quarter
the Compass draw lines, to cut the parallel of
Latitude EH, as A 1. A 2. A 3. A 4. &c. whi
shall be the respective distances upon each poi
for raising the Pole one Degree, and if AE
60 miles, A 1. shall be 61 miles, A 2. 65 mil
A 3. 72 miles, A 4. 85 miles. A 5. 108 mil
A 6. 157 miles, A 7. 337 miles, and lastly,
Sayling East or West (which is the eight poin
you neither can raise nor depress the Pole, beca
you always keep of an equal distance from it.

PROP. 4. Fig. 33.

*The Longitude of two places, the Latitude of on
them, and the Course given, to find their dista
and the Latitude of the other place.*

Let one place lie at A in the N°. Latitude
48°. 00′ and Longitude of 20°. 00′. the other
in the Longitude of 22°. the Course between
them being NE.

From G a point in the Longitude of 22°. draw
the line GB parallel to AI, then from A draw
the NE line A 4 B to cut the parallel line GB in
B. Lastly, from B draw BC parallel to AF, so
shall the Chart shew that the place B lyes in the
N°. Latitude of 50°. 00′. and AB applyed to
AE

E will reach from A to D. hence it is evident that the distance between A and B is 56 leagues.

PROP. 5. Fig. 33.

The Latitude of any two places and their distance given, with the Longitude of one of them, to find the Longitude of the other, and the Course from the one to the other.

Let one place be A in the N°. Latitude of 48° 00' and Longitude of 20°. let the other place lie in the N°. Latitude of 50°. 00'. the distance between them being 56 Leagues.

Out of the line AF take the distance given, viz. AD 56 leagues, or 2°. 48' then from A with the distance AD cross the Parallel of 50°. 00'. in B. Lastly, draw the line AB, so shall it appear from the Chart that the place B lies in the Longitude of 22°. 00'. and that the Course from A to B is 4 points from the North Eastward, that is NE.

PROP. 6. Fig. 33.

The Longitude of any two places, the Latitude of one of them, and their distance given to find the Latitude of the other place and the Course between them.

Let one place be A in the N°. Latitude of 48°. 00' and Longitude of 20°. 00'. and let the other place lie in the Longitude of 22. 00'. the distance between the two places being 56 leagues.

Upon

Upon G a point in the Longitude of 22°. draw GB parallel to AI, then from the line take 2°. 48′. or 56 leagues, *viz.* AD, with setting one foot in A, cross the line GB in B, draw AB. Lastly, through B, draw BC parallel, to AF, so shall B be the second place required, whose Latitude is 50°. and from the Quadrant described upon A, it is evident that Course from A to B is NE.

PROP. 7. Fig. 33.

To work a Traverse by the Plain Chart.

A Ship from the N°. Latitude of 50°. 00′ Longitude of 20°. 00′ sayls NNE 26 leagues NE, 30 leagues North 22 leagues, East 24 leagues SE 26 leagues SSW 23 leagues, ENE 25 leagues, NE 27 leagues, and NNW 32 leagues, bound to a Port lying in the N°. Latitude of and Longitude of 23°. 00′. I demand her titude and longitnde, Course and distance upon a strait line, and her bearing and distance from the Port.

Lay a Ruler upon A, and the NNE line, from C by the side thereof, draw the line C parallel to it, then from AF take 26 leagues which set from C to ♈, that done, lay a Ruler upon A and the NE, and from ♈ draw ♈ parallel thereto, upon which set 30 leagues from ♈ to ♉ also from ♉ (because the next Course is North) draw ♉ ♊, parallel to AI, and 22 leagues from ♉ to ♊ then from ♊ draw ♊ ♋ parallel to AF (because the Course is East and set 24 leagues from ♊ to ♋, then lay a Ruler upon

n I and the SE point of the Compass, and from
draw a line parallel to the side thereof as ♋ ♌,
n which line set 26 leagues form ♋ to ♌, then
a Ruler on E and the SSW point, and from
draw the SSW line ♌ ♍ parallel to the side
reof, and set 23 leagues from ♌ to ♍, that
ne, lay a Ruler upon A and the ENE point,
from ♍ draw the ENE line ♍ ♎ upon which
25 leagues from ♍ ♎, also lay a Ruler on A
the NE point, and from ♎ draw ♎ ♏ paral-
to the side thereof, upon which set 27 leagues
m ♎ to ♏. Lastly, lay a Ruler on F and on
NW point, and from ♏ draw ♏ ♐ parallel
the side thereof for a NNW line, and
32 leagues from ♏ ♐: So have you finished
the Courses of the Traverse.

To find the Ships Latitude, Longitude Course
Distance run upon a straight line, do thus.

Draw the line C ♐, and from ♐ draw ♐ ♓
rallel to AF, ♐ ♒ parallel to FE, so shall the
art shew you that the Ship is in the N. latit.
54°. 24′. and longitude 24°. 42′. Also from
with the Radius AK strike the Arch LM,
ich applied to the Quadrant KN will reach
m K to R, hence it is evident that the Course
m C to ♐ is NE 2°. 00′ Eastward, and the
tance C ♐ measured upon the line EF or AI,
ll reach from F to O, *viz.* 6°. 24′. or 128
gues.

To find the Course and distance between the
ip and Port, draw the line ♐ ♑, because the
rt lies at ♑ from ♐ with the distance AK
ike the Arch PQ, which measured upon
Quadrant KN will reach from K to R almost;

hence the Course from ♐ to ♑ is NW 1°. West, and ♐ ♑ is their distance, which red upon the line EF gives 2°. 19′. or leagues.

CHAP. XII.

Of Plain Sailing.

THE business of plain Sailing consists in Logarithmical solution of such Tri as are drawn upon the plain Chart. What the Chart is I have formerly declared, as also what Hypothesis it is grounded: there rem nothing more to be done, but only to shew Logarithmical solution of these Nautical angles, which are usually divided into 6 fol ing Cases.

Before I undertake the solution of the six lowing Cases, it will not be amiss to pre these general Rules.

RULE I.

The Ship in North Latitude.

1. If the Course be Northward, she raiseth elevateth the Pole, and therefore the diff. La

(red

reduced into Degrees and Minutes) must be added to the Latitude, from whence the Ship came; and that sum shall be the Ship's true Latitude North.

2. If the Course be Southward she depresseth the Pole, or decreaseth her Latitude; and then the diff. Latitude in Deg. and Min. must be subtracted from the Latitude she departed; and the remainer shall be the Ship's Latitude North.

3. If the Course be Southward, and the diff. of Latitude reduced into Degrees and Minutes exceed the Latitude she came from; subtract the said Latitude from this reduced difference of Latitude, and the remainer shall be the Ship's Latitude South: and consequently the Ship hath crost the Equinoctial.

RULE 2.

The Ship in South Latitude.

1. If the Course be Southward, the Ship raiseth the Pole, or encreaseth her Latitude; and then the diff. Latit. reduced into D. M. must be added to the Latitude from whence the Ship departed, and the sum shall be the Ship's Latitude South.

2. If the Course be Northward, she decreaseth her Latitude; and therefore the difference of Latitude reduced into D. M. must be subtracted from the Latitude she departed, and the remainer shall be the Ship's latitude South.

3. If the Course be Northward, and the diff. latitude reduced into D. M. exceeded the latitude she came from, subtract this said latitude from the reduced diff. of latitude, and the remainder shall be the ship's latitude N°. and consequently she hath cross'd the Equinoctial.

RULE 3.

Having the Latitude of any two Places given, to find the difference of Latitude.

1. If the two places lie both in the North, or both in South latitude, subtract the lesser latitude from the greater; the remainder shall be the Difference of latitude in Degrees and Minutes

2. If one place lie in North latitude, and the other in South latitude, add the two latitudes together, and the sum shall be the diff. latitude in Deg. and Min.

The Reduction of degrees and minutes into miles (or leagues) both Sexagenary and English, was fully expressed in Chap. 10.

RULE 4.

To find whether you must Sail Northward or Southward, between any two places whose Latitudes are known.

1. If you sail from a greater N°. latit. to a lesser, the Course is Southward; but if from a lesser N°. latitude to a greater, the Course is Northward.

2.

2. If you sail from a greater South latitude to a lesser, the Course is Northward: but if from a lesser South latitude to a greater, the Course is Southward.

3. If you sail from a No. latitude to a South latitude, the Course is Southward: but if from a South latitude to a North latitude, the Course is Northward.

RULE 5.

To find the Ship's Longitude.

1. If the Course be Eastward, the longitude increaseth, and therefore the diff. longitude reduced into D. M. must be added to the longitude from which the ship departed, and the sum shall be the ships present longitude: But if the Course be Westward she decreaseth her longitude; and therefore the diff. of longitude reduced into D.M. must be subtracted from the longitude she departed, and the remainer shall be the ships present longitude.

2. If the Course be Eastward and the sum of the ships longitude and reduced diff. longitude exceed 360°. subtract 360°. from this sum, and the remainer shall be the ship's true Longitude, and consequently the ship hath crost the First Meridian.

3. If the Course be Westward, and the diff. longit. reduced into D. M. exceed the longitude she came from, subtract this said longitude from this reduced diff. longit. and the remainer subtracted from 360°. shall give the ship's present longitude.

RULE 6.

Having the Longitude of any two Places given, find the diff. Longitude between them.

Subtract the lesser from the greater Longitude, and the remainer (being less than 180°.) shall be the diff. longitude required. But if this remainer exceed 180°. subtract it from 360°. and the remainer shall be the true diff. longitude in Deg. and Minutes.

RULE 7.

To find whether you must Sail Eastward or Westward, between any two places, whose Longitudes are known.

1. If you Sail from a lesser longitude to a greater, the Course is Eastward; but if from a greater to a lesser, the Gourse is Westward.

2. If you cross the first Meridian, and sail from a greater longitude to a lesser, the Course is Eastward; and if (crossing the first Meridian) you sail from a lesser to a greater longitude, the Course is Westward.

ANNOTATION.

Our Modern Geographers do many times place the first Meridian over the Metropolis of that Country wherein they were born; and thereby do distinguish the longitudes of places into

to East and West longitude, accounting all those places which lie to the Eastward of this Metropolitan Meridian to lie in East longitude: and all those places which lie to the Westward thereof, to lie in West longitude.

Hence it is evident that the Longitude of places thus distinguished, cannot exceed 180 Degrees.

RULE 8.

The Ship in East Longitude.

1. If the Course be Eastward, she encreaseth her longitude, and therefore the different longitude reduced into Deg. and Min. must be added to the longitude she came from, and the sum shall be the Ship's longitude East: but if this sum exceed 180 Degrees, subtract it from 360°. and the remainer shall be the Ship's longitude West.

2. If the Course be Westward, she decreaseth her longitude, and therefore the diff. longitude reduced into Degrees and Minutes, must be subtracted from the longitude she departed, and the remainer shall be the Ship's longitude West.

3. If the Course be Westward, and the diff. longitude reduced into D. M. exceeds the longitude she came from, subtract the said longitude from the reduced diff. longitude, and the remainer shall be the Ship's longitude West: and consequently the Ship hath crost the first Meridian.

RULE 9.

The Ship in West Latitude.

1. If the Course be Westward, the longitu encreaseth, and therfore the diff. longit. re ced into D. M. must be added to the longitu she came from; and the sum being less than 18 shall be the Ship's longit. West. But if this s exceed 180°. subtract it from 360°. and the re mainer shall be the Ship's longitude East.

2. If the Course be Eastward, the longitu decreaseth, and therefore the diff. longit. re ced into D. M. must be subtracted from the lo gitude she departed, and the remainer shall b the Ships longitude West.

3. If the Course be Eastward, and the di longit. reduced in D. M. exceed the longitu she came from, subtract the said longitude fr this reduced diff. longit. and the remainer sh be the Ship's longitude East, and consequen the Ship hath crost the first Meridian.

RULE 10.

The Longitude of any two places (distinguished by Ea and West Longitude) given, to find the diff. Lo gitude between them.

1. If the two places lie both in East, or bot in West longitude, subtract the lesser from th greater, and the remainer shall be the diff. longi tude in D. M.

2. If

2. If one place lie in East, and the other in West longitude, add them together, and their sum being less than 180°. shall be the diff. longitude between them. But if this sum exceed 180°. subtract it from 360°. and the remainer shall be the diff. Longitude required.

RULE 11.

To find whether you must Sail Eastward or Westward, between any two places in East or West Longitude.

1. If you sail from a greater East longitude to a lesser, the Course is Westward: but if from a lesser to a greater East longitude, the Course is Eastward.

2. If you sail from a greater West longitude to a lesser, the Course is Eastward: but if from a lesser West Longitude to a greater, the Course is Westward.

3. If you sail from a place in East longitude to a place in West longitude, the Course is Westward, except you cross the first Meridian, and then the Course is Eastward, and the contrary.

RULE 12.

Having the angle of the Course, and Quarter of the Compass you have sailed in, to find the Ship's Rumb.

Seek in the foregoing Table of Points in *Pag.* 161 for the nearest whole point to the angle of the Course; and if the angle of the Course be greater than the nearest whole point, then you have sailed to the Eastward or Westward of that whole point.

But

hence the Courſe from ‡ to ♈ is NW 1°. ... Weſt, and ‡ ♈ is their diſtance, which mea- red upon the line EF gives 2°. 19′. or 46 leagues.

CHAP. XII.

Of Plain Sailing.

THE buſineſs of plain Sailing conſiſts in the Logarithmical ſolution of ſuch Triangles as are drawn upon the plain Chart. What the plain Chart is I have formerly declared, as alſo upon what Hypotheſis it is grounded: there remains nothing more to be done, but only to ſhew the Logarithmical ſolution of theſe Nautical Triangles, which are uſually divided into 6 following Caſes.

Before I undertake the ſolution of the ſix following Caſes, it will not be amiſs to premiſe theſe general Rules.

RULE I.

The Ship in North Latitude.

1. If the Courſe be Northward, ſhe raiſeth or elevateth the Pole, and therefore the diff. Lati-

(redu-

reduced into Degrees and Minutes) must be added to the Latitude, from whence the Ship came; and that sum shall be the Ship's true Latitude North

2. If the Course be Southward she depresseth the Pole, or decreaseth her Latitude; and then the diff. Latitude in Deg. and Min. must be subtracted from the Latitude she departed; and the Remainer shall be the Ship's Latitude North

3. If the Course be Southward, and the diff. of Latitude reduced into Degrees and Minutes exceed the Latitude she came from; subtract the said Latitude from this reduced difference of Latitude, and the remainer shall be the Ship's Latitude South: and consequently the Ship hath crost the Equinoctial.

RULE 2.

The Ship in South Latitude.

1. If the Course be Southward, the Ship raiseth the Pole, or encreaseth her Latitude; and then the diff. Latit. reduced into D. M. must be added to the Latitude from whence the Ship departed, and the sum shall be the Ship's Latitude South.

2. If the Course be Northward, she decreaseth her Latitude; and therefore the difference of Latitude reduced into D. M. must be subtracted from the Latitude she departed, and the remainer shall be the Ship's latitude South.

3. If the Course be Northward, and the diff. latitude reduced into D. M. exceeded the latitude she came from, subtract this said latitude from the reduced diff. of latitude, and the remainer shall be the ship's latitude N°. and consequently she hath crost the Equinoctial.

RULE 3.

Having the Latitude of any two Places given, to find the difference of Latitude.

1. If the two places lie both in the North, or both in South latitude, subtract the lesser latitude from the greater; the remainer shall be the Difference of latitude in Degrees and Minutes

2. If one place lie in North latitude, and the other in South latitude, add the two latitudes together, and the sum shall be the diff. latitude in Deg. and Min.

The Reduction of degrees and minutes into miles (or leagues) both Sexagenary and English, was fully expressed in Chap. 10.

RULE 4.

To find whether you must Sail Northward or Southward, between any two places whose Latitudes are known.

1. If you sail from a greater N°. latit. to a lesser, the Course is Southward; but if from a lesser N°. latitude to a greater, the Course is Northward.

2.

2. If you sail from a greater South latitude to lesser, the Course is Northward: but if from a lesser South latitude to a greater, the Course is Southward.

3. If you sail from a No. latitude to a South latitude, the Course is Southward: but if from a South latitude to a North latitude, the Course is Northward.

RULE 5.

To find the Ship's Longitude.

1. If the Course be Eastward, the longitude encreaseth, and therefore the diff. longitude reduced into D. M. must be added to the longitude from which the ship departed, and the sum shall be the ships present longitude: But if the Course be Westward she decreaseth her longitude; and therefore the diff. of longitude reduced into D.M. must be subtracted from the longitude she departed, and the remainer shall be the ships present longitude.

2. If the Course be Eastward and the sum of the ships longitude and reduced diff. longitude exceed 360°. subtract 360°. from this sum, and the remainer shall be the ship's true Longitude, and consequently the ship hath crost the First Meridian.

3. If the Course be Westward, and the diff. longit. reduced into D. M. exceed the longitude she came from, subtract this said longitude from this reduced diff. longit. and the remainer subtracted from 360°. shall give the ship's present longitude.

RULE 6.

Having the Longitude of any two Places given to find the diff. Longitude between them.

Subtract the lesser from the greater Longitude, and the remainer (being less than 180°.) shall be the diff. longitude required. But if this remainer exceed 180°. subtract it from 360°. and the remainer shall be the true diff. longitude in Deg. and Minutes.

RULE 7.

To find whether you must Sail Eastward or Westward, between any two places, whose Longitudes are known.

1. If you Sail from a lesser longitude to a greater, the Course is Eastward; but if from a greater to a lesser, the Course is Westward.

2. If you cross the first Meridian, and sail from a greater longitude to a lesser, the Course is Eastward; and if (crossing the first Meridian) you sail from a lesser to a greater longitude, the Course is Westward.

ANNOTATION.

Our Modern Geographers do many times place the first Meridian over the Metropolis of that Country wherein they were born; and thereby do distinguish the longitudes of places

to East and West longitude, accounting all those places which lie to the Eastward of this Metropolitan Meridian to lie in East longitude: and all those places which lie to the Westward thereof, to lie in West longitude.

Hence it is evident that the Longitude of places thus distinguished, cannot exceed 180 Degrees.

RULE 8.

The Ship in East Longitude.

1. If the Course be Eastward, she encreaseth her longitude, and therefore the different longitude reduced into Deg. and Min. must be added to the longitude she came from, and the sum shall be the Ship's longitude East: but if this sum exceed 180 Degrees, subtract it from 360°. and the remainer shall be the Ship's longitude West.

2. If the Course be Westward, she decreaseth her longitude, and therefore the diff. longitude reduced into Degrees and Minutes, must be subtracted from the longitude she departed, and the remainer shall be the Ship's longitude West.

3. If the Course be Westward, and the diff. longitude reduced into D. M. exceeds the longitude she came from, subtract the said longitude from the reduced diff. longitude, and the remainer shall be the Ship's longitude West; and consequently the Ship hath crost the first Meridian.

RULE 9.

The Ship in West Latitude.

1. If the Course be Westward, the longitude encreaseth, and therfore the diff. longit. reduced into D. M. must be added to the longitude she came from; and the sum being less than 180. shall be the Ship's longit. West. But if this sum exceed 180°. subtract it from 360°. and the remainer shall be the Ship's longitude East.

2. If the Course be Eastward, the longitude decreaseth, and therefore the diff. longit. reduced into D. M. must be subtracted from the longitude she departed, and the remainer shall be the Ships longitude West.

3. If the Course be Eastward, and the diff. longit. reduced in D. M. exceed the longitude she came from, subtract the said longitude from this reduced diff. longit. and the remainer shall be the Ship's longitude East, and consequently the Ship hath crost the first Meridian.

RULE 10.

The Longitude of any two places (distinguished by East and West Longitude) given, to find the diff. Longitude between them.

1. If the two places lie both in East, or both in West longitude, subtract the lesser from the greater, and the remainer shall be the diff. longitude in D. M.

2. If

2. If one place lie in East, and the other in West longitude, add them together, and their sum being less than 180°. shall be the diff. longitude between them. But if this sum exceed 180°. subtract it from 360°. and the remainer shall be the diff. Longitude required.

RULE 11.

To find whether you must Sail Eastward or Westward, between any two places in East or West Longitude.

1. If you sail from a greater East longitude to a lesser, the Course is Westward: but if from a lesser to a greater East longitude, the Course is Eastward.

2. If you sail from a greater West longitude to a lesser, the Course is Eastward: but if from a lesser West Longitude to a greater, the Course is Westward.

3. If you sail from a place in East longitude to a place in West longitude, the Course is Westward, except you cross the first Meridian, and then the Course is Eastward, and the contrary.

RULE 12.

Having the angle of the Course, and Quarter of the Compass you have sailed in, to find the Ship's Rumb.

Seek in the foregoing Table of Points in *Pag.* 161 for the nearest whole point to the angle of the Course; and if the angle of the Course be greater than the nearest whole point, then you have sailed to the Eastward or Westward of that whole point.

But

But if the angle of the Courſe be leſſer than the neareſt the whole point, you have ſailed to the Northward or Southward thereof.

Examples of all theſe Rules follow in the enſuing Caſes.

PLAIN SAILING.

CASE 1. Fig. 34.

Courſe and Diſtance run, given to find the Ships Latitude and Longitude, by Plain Sailing.

A Ship from the North latitude 50°. 00′ and longitude of 70°. 00′. Sails NEBE 130 leagues. I demand her latitude and longitude.

GEOMETRICALLY.

Draw the line AB to repreſent the Ship's firſt Meridian, or North and South line. From A with the Chord of 60°. ſtrike the Arch DE, and from the ſame line of Chords take the angle of the Courſe, *viz.* 56°. 15′. which ſet from D to E, and draw the line AE.

From the line of equal parts take 130 leagues, which apply from A to C. Divide AC equally in F, and from F, with the diſtance AF croſs the Meridian

ian AB in B. Lastly, draw BC, so shall AB be the diff. Latit. in leagues, and BC the diff. longitude in leagues, both which must be measured upon the line of equal parts.

LOGARITHMICALLY.

By Case 3 of Plain Triangles

R. AC : : S, A : BC. that is,

As the Radius sine of 90°.00′. *viz.* AC	1000000
Is to the distance run AC 130 leagues	211394
So is sine of the Course, ang. BAC 56°.15′.	991984
To the diff. longit. in leagues BC 108	203378

This diff. longit. reduced into degrees and minutes, gives 5°. 24′. therefore by 1. Rule 5. the Ship (according to the Plain Chart) is in the longitude of 75°. 24′.

Again, R. AC : : S, C : AB. that is

As Radius AC, sine of 90°. 00′.	1000000
Is to the distance run AC 130 leagues	211394
So is sine of the angle ACB 33°. 45′,	974473
To the diff. Laitit. in leagues, AB 72.	185867

This diff. latitude reduced into Deg. and Min. gives 3°. 36′. therefore by 1. Rule 1. the Ship is in the North latit. 53°. 36′.

CASE 2. Fig. 35.

Both Latitudes and Course given, to find the Longitude and distance.

A Ship from the Equinoctial, and longitude of 2°. 10′. West sails NEBE to the latitude of 3°. 36.

36'. N°. I demand her longitude and distance run.

GEOMETRICALLY.

Draw the line AB to represent the Ship's first Meridian or N°. and S°. line. From A with the Chord 60°. 00'. Strike the Arch DE, and from the same line of Chords take the angle of the Course, *viz.* 56°. 15'. which apply from D to E, and draw the line CA. By the Rule 3. it is evident that the diff. Latitude is 3°. 36'. which reduced into leagues make 72 leagues. From the equal parts take 72 leagues, which apply from A to B. Upon B erect the perpendicular BC, to cut the line AC in C. So have you finished the plain sailing Triangle ABC, in which AB is the difference of latitude, AC the distance run, and BC the difference of longitude required. All which must be measured upon the same line of equal parts.

LOGARITHMICALLY.

S C : A B : : R : A C, that is,

As sine of the angle at C 33°. 45'.	974473
Is to the diff. latit. AB 72 leagues	185733
So is Radius AC sine of 90°. 0'.	1000000
To the ships distance run AC 130 leag.	211260

Again,

Again, S, C. AB : : S, A : BC. that is,

As sine of the angle C 33°. 45′.	974473
to diff. latitude AB 72 leagues	185733
is the Sine of the Course an. BAC 56°. 15.	991984
	1177717
To the ships diff. longit. BC 108 leag.	203244

This diff. longit. reduced into D.M. (by dividing by 20 the leagues in one deg.) gives 5°. 24′. for the diff. longit. in D. M. therefore by 3. Rule 8. the ship is in the East longit. of 3°. 14′.

CASE 3. Fig. 36.

Both Longitudes and Course given, to find the Ships Latitude and Distance run.

A ship from the N°. latitude of 2°. 00′. and East longit. of 178°. 00′. sails SEBE to the West longit. of 176. 21. I demand her latitude and distance run.

GEOMETRICALLY.

Draw the line BC to represent the Ships diff. longit. from C with the Chord of 60°. 00′. strike the Arch DE, upon which set the Complement of the Course *viz*. 33°. 45′ from D to E, and draw the line CE at length. Then by 2. Rule 10. find the ship's diff. longit. *viz*. 5°. 39′. or 113 leagues; which take from the line of equal parts, and set from C to B, upon B erect the perpendic. BA to cut the line CE continued, in A. So have you finished the plain

sailing

sailing Triangle ABC, in which AB is the d
Latit. and AC the distance run.

LOGARITHMICALLY.

S, A : BC : : R. AC, that is,

As sine angle A 56°. 45′.		9919
Is to diff. longit. in leagues BC 113		2053
So is Radius AC, sine of 90°. 00′		10000
To the distance in leagues AC 136		2133

Again, S, A : BC : : S, C : AB. that is

As sine angle A 56°. 15′		9919
Is to diff. longit. in leagues BC 113		2053
So is Sine angle C 33°. 45′.		9744
		11797
To the diff. latit. in leagues AB. 76		1877

which reduced into D. M. make 3°. 48′, there-
fore by 3. Rule 1. the ship is in the South lati
of 1°. 48′.

CASE 4. Fig. 37.

Both Latitudes and distance run, given to find the Course and Ship's Longitude.

A ship from the South latitude of 28°. 00′. and
longitude of 358°. 00′. is bound for a Port in
the South latit. 51°. 10′ distant from her 136
leagues to the Eastward. I demand her Course, and
longitude of the Port.

GEO-

GEOMETRICALLY.

Draw AB for the Meridian the Ship comes om, and by 1. Rule 3. find the diff. latitude, iz. 3°. 30'. or 70 leagues, then by 2 Rule 4 set is reduced dist. latit. from A to B. Upon B ect the perpendicular BC. Take the distance gi- en, in your Compasses, and with one foot in A ross the line BC in C, then draw AC, and from A with the Chord of 60°. strike the Arch DE, o have you finished the Plain Sailing Triangle BC, whose parts are easily known.

LOGARITHMICALLY.

AC. R : : AB : S, C. that is

As the distance run AC 136 leagues	213353
s to Radius AC Sine of 90°. 00'.	1000000
So is the diff. latitude AB 70 leagues	184509
To sine of the angle at C 30°. 58'.	971156

which subtracted from 90°. 00'. the remainer 59°. 2' is the angle of the Course, *viz.* CAB, therefore by Rule 12, the Course from A to C is SEBE 2°. 47' Eastward.

Again, R. AC : : S, A : BC. that is.

As Radius AC. sine of 90°. 00'.	1000000
Is to distance run AC 136 leagues	213353
So is sine of the angle at A 59°. 2'	993321
To diff. longitude in leagues BC 116	2 6674

which

which reduced into D. M. gives 5°. 48'. therefore by 2. Rule 5. the Ship is in the Longitude of 3°. 48'.

CASE 5. Fig. 38.

Both Longitudes and distance run given, to find the Course and Ship's Latitude.

A Ship from the North latitude of 46°. 00' and longitude of 2°. 00'. sails between the North and West 120, to the longitude of 357. I demand her Course and latitude.

GEOMETRICALLY.

Draw the line CB, and by Rule 6 find the Ship's diff. longitude, which is 5°. 00'. this reduced into leagues makes 100, therefore set 100 leagues from C to B. From B let fall the perpend. BA. Take 120 leagues (the Ship's distance run) in your Compass, and with one foot in C, cross the perpend. BA in A. Draw the line CA, and from A with the Chord of 60°. strike the Arch DE, which measured upon the same line of Chords, gives 56°. 27'. for the angle of the Course. Therefore by Rule 12, the Ship's Course is NWBW 00°. 12'. Westward.

LOGA-

LOGARITHMICALLY.

AC: R :: BC: S. A. that is,

As the distance run AC 120 leagues	207918
to Radius AC, Sine of 90°. 00'.	1000000
is the diff. longitude BC 100 leagues	200000
So Sine Ang. of the Course BAC 56°. 27'.	992082

Again, S, A : BC :: R : AC, that is,

As Sine Angle A 56°. 27'.	992082
to diff. longitude BC 100 leagues	200000
is Sine Angle C 33°. 33'.	974246
	1174246
So the diff. latitude AB 66 leagues	182164

which reduced into D. M. make 3°. 18'. Therefore by 1. Rule 1. the Ship is in the N°. latitude 49°. 18'.

CASE 6. Fig. 39.

Both Latitudes and both Longitudes given, to find the Course and distance.

Admit there be two several Ports, the one in the North latitude of 52°. and longitude of 58°. 00'. the other in the North latitude of 48°. and longitude of 53. 00. I demand the Course and distance between them.

GEOMETRICALLY.

By 1. Rule 3. find the diff. latitude, viz.
0 ′. or 80 leagues, and by 1. Rule 4. you
find the Course to be Southward; therefore dr
the line AB, and set 80 leagues from A to B. A
so by 6 Rule find the diff. of longitude, viz.
00′. or 100 leagues, and by 1. Rule 7 it is evid
the Course must be Westward. Therefore fr
B draw BC perpend. to AB. upon which set
leagues from B to C, then draw the line AC wh
shall be the distance between the two Ports. La
ly, from A with the Chord of 60°. strike
Arch DE which shall give the measure of
Angle of the Course.

LOGARITHMICALLY.

AB : R : : BC : t, A. that is,

As the diff. latitude AB 80 leagues	190
Is to Radius AC, Sine of 90°. 00′.	1000
So is diff. longitude BC 100 leagues	200
To Tang. of the Course, ang. BAC. 51.21	1009

Therefore by Rule 12. the Course will be S
6°. 21′. Westward, or SWBW 4°. 54′. So
ward.

Again, S, A : BC : : R : AC. that is,

As Sine angle of the Course 51°. 21′.	989
Is to diff. Longitude BC 100 leagues	200
So is Radius AC. Sine of 90 . 00′.	1000
To the distance run AC 128 leagues	210

To work a Traverse by Plain Sailing.

FIG. 40.

A Ship from the North latitude of 24°. 30'. and East longitude of 48°. 40'. is bound to a Port in the North latitude 27°. 06'. and East Longitude 51. 34. she sails NNW 21, North 20. NNE 24, NE 25, East 37, NWBN 22. South 48, and SEBS 47 leagues. I demand her latitude, longitude, course and distance run upon a streight line, and her bearing and distance from the Port.

GEOMETRICALLY.

Draw the line YAX for an East and West line. Upon A erect the perpendicular AZ for a North and South line. From A (with any distance) strike the semicircle, which divide into 16 equal parts, to represent the several Points of the Compass: Lay a Ruler upon A, and on each of these 16 Points, and draw lines A 1. A 2. A 3. as in the Figure.

Then because the first course is NNW 21 leagues, take 21 leagues from the line of equal parts, and set the same from A to B. Lay a Ruler upon A Z, and from B draw a line parallel to

the side thereof as BC, to represent a N°. line. Upon this line set 20 leagues from B to C. Also lay a Ruler on the NNE line A 2, and from C draw a line parallel to the side thereof as CD, for the NNE line, upon which set 24 leagues from C to D. Again, lay a Ruler upon the NE line A 4, and from D draw a line parallel to the side thereof, as DE, upon which set 25 leagues from D to E. Then lay a Ruler upon the East line YAX, and from E draw a line parallel thereto as EF, upon which set 37 leagues from E to F. Also lay a Ruler upon the NWBN line A 3, and from F draw F G parallel thereto, upon which set 31 leagues from F to G; lay a Ruler upon the South line ZA, and from G draw GH parallel thereto; upon which set 48 leagues from G to H. Lastly, lay a Ruler upon the SEBS line, or rather its opposit, the NWBN line A 3, and from H draw HI parallel thereto, upon which set 47 leagues from H to I. So have you finished the Traverse. Then to find the ship's diff. latitude, &c. draw the line AI, which divide into two equal parts in M. From M with the distance AM cross the line AZ in N. So shall AN be the ship's diff. latitude, NI her diff. longit. AI her distance run, and NAI the angle of her course; all which may be measured upon the line of equal parts, and Chords.

To protract the Port, you must by 1 Rule 3, find the diff. latitude between the two Ports, viz. 2°. 56'. or 52, Leagues and by 1 Rule 10 find their diff. longitude, *viz.* 2°. 54'. or 58 leagues, which being known, set 52 leagues from A to O. Draw OK parallel to AX, and upon OK set 58 leagues from

from O to K. Then draw I K, which shall be the distance between the Ship and Port. Also continue OK to L, making OL equal to NI. Lastly draw IL, so shall IL be the diff. latitude between the ship and Port, and KL the diff. longitude between them.

ARITHMETICALLY.

The Ship's Latitude and Longitude may be most expeditiously found in the Traverse Tables, whose use I have explained immediately before the Tables; and so the diff. latitude and longit. upon each course and distance for the foregoing Traverse will be as followeth.

O 3

Courses	Leagues	Miles	Miles Northing	Southing Miles	Miles Easting	Miles Westing
NNW	21	60 3	55433 2771			22961 1148
North	20	60	60000			
NNE	24	70 2	64672 1848		126788 0765	
NE	25	70 5	49498 3535		49498 3535	
East	37	100 11			111000	
NWBN	32	90 6	74832 4988			50001 3333
South	48	100 40 4		144000		
SEBS	47	100 40 1		83147 33259 0831	55557 22223 0555	
			317.577	261.237	269.921	77.44[illegible]

Thus it appears that the sum of the Northing Column is 317. 577 miles; of the Southing 261. 237 miles; of the Easting 269. 921 miles, and of the Westing 77. 443 miles. Subtract the sum of the southing Column from the sum of the northing Column, the remainer 56. 34 miles is the Ship's diff. Latitude; therefore by 1. Rule 1. the Ship is in the North Latitude 25°. 26′.

Also

Also (because the Westermost Column is the least) subtract 77. 443. the sum of the Westerly Column, from 269. 921 the sum of the Easterly Column, the remainder 192. 478 is the number of Miles in the diff. of Longitude; therefore by 1. Rule 8. the Ship is in the East Longitude 51°. 52.

To find the Ships Course and distance run upon a straight line, say by Case 6. plain Sailing.

As the diff. Latit. 56. 34 miles	AN	1750817
Is to Radius Sine of 90°. 00'.		10000000
So is the diff. Longitude 192. 48 miles	IN	2284385
To Tang. ship's Course 73°. 41'.	NAI	10533568

As Sine of the Course 73. 41.	NAI	9982146
Is to diff. Longitude 192. 48. miles	IN	2284385
So is Radius Sine of 90°. 00'.		10000000
	AI	
To the ship's distance run 200. 57 Miles		2302154

By Rule 12. it is evident that the ship's Course is ENE 6°. 11' Easterly, or EBN 5°. 4'. Northward.

By 1. Rule 3. if you subtract the ship's diff. Latitude AN from the Ports diff. Latitude AO, the remainer will be NO 99. 66. Miles, the diff. Latit. between the Ship and Port, equal to IL.

Also by 1. Rule 8. if you subtract the Ports diff. Longit. OK from the ship's diff. Longit. IN, the remainer 18. 48. Miles equal to KL will be the diff. Longit. between the ship and Port.

Then to find the Course and distance from the Ship to the Port, say

As diff. lat. bet. Ship and Port, IL 99.66.		19985
Is to Radius Sine of 90°. 00′.		100000
So is diff. long. bet. Ship & Port KL 18.48		12667
To Tang. angle KIL 10°. 31′.		92681

As Sine angle KIL 10°. 31′.		926131
Is to Radius Sine of 90°. 00′.		100000
So is diff. longitude KL 18. 48.		12667
To dist. bet. the Ship and Port 101.2.M.		20053

Therefore by Rule 12. the Course from I to K NBW 00°. 44′. North.

CHAP. XIII.

The Solution of Plain Sailing Questions, by the (so called) Tables of given Numbers.

THE Table of given Numbers is nothing else but a Table of Natural Sines and Tangents answering to each point, ½ point and ¼ point of the Compass.

A Table of Natural Sines and Tangents to every Point, ½ Point and ¼ Point of the Compass.

Points.	Sines	Points.	Sines	Points.	Tang.	Points.	Tang.
	49		741		44		1103
	98		773		98		1218
	147		803		148		1348
1	195	5	831	1	199	5	1496
	243		858		250		1668
	290		882		303		1870
	337		904		358		2188
2	383	6	924	2	414	6	2414
	428		941		473		2795
	471		957		533		3249
	515		970		599		3991
3	555	7	981	3	668	7	5112
	596		989		742		6749
	634		995		82·		10138
	671		999		906		20205
4	707	8	1000	4	1000	8	Infinite.

The use of this Table.

CASE 1.

Course and Distance given, to find the Ships diff. Latitude and Departure.

A Ship Sails NEBE 120 leagues, I demand her diff. Latitude and departure.

1. Multiply the distance run 120 by the Sine of the Course 831. that Product 99720 divided by 1000, the Quotient 99. 720 leagues is the departure.

2. Multiply the distance run 120 by the Compt. of the Course 555, that Product 66600 divided by 1000 gives 60. 6 for the different Latitude.

Note, Seeing that the Longitudes of Places cannot be truly exprest upon the Plain Chart, because the Construction thereof depends upon a false Hypothesis, therefore what I called in the preceding Problems, by the name of difference of Longitude, ought rather to be called departure, or Easting and Westing; because it only shews the distance of any two Meridians in any Parallel of Latitude, but not the same distance of those two Meridians at the Equinoctial.

CASE

CASE 2.

Course and diff. Latitude given, to find the departure and distance run.

A Ship sails NNW till her diff: latitude be 75 leagues. I demand her departure and distance run.

1. Multiply the diff. latitude 75 by the Sine of the Course 383, that Product 28725 divided by the Co-sine of the Course 924, gives 31 leagues for the departure.

2. Multiply the diff. latitude 75 by 1000, that Product 75000 divided by the Co-sine of the Course 924, gives 81 leagues for the diff. latitude.

CASE 3.

Course and Departure given, to find the Ship's diff. Latitude and distance run.

A Ship sails NWBN till her departure be 78 leagues. I demand her diff. Latitude and distance run.

1. Multiply the departure 78 by 1000, that Product 78000 divided by the Sine of the Course 555, gives 140 leagues for the distance run.

2. Multiply the departure 78, by the Co-sine of the Course 831, that Product 64818 divided by the Sine of the Course 555, gives 116 for the diff. Latitude.

CASE

CASE 4.

Distance run and diff. Latitude given, to find the Course and Departure.

A Ship sails between the North and the East 120 leagues, till her diff. latitude be 66. 60 leagues. I demand her Course and Departure.

1. Multiply the diff. latitude 66. 60 by 1000. that Product 666000 divided by the distance run 120, gives 555, which seek for in the foregoing Table, and you will find answering thereto, 3 points of the Compass of the Course, then (because each quarter of the Compass contains 8 points) Subtract three points from eight points, the remainer will be five points. So the Course required will be NEBE.

2. Multiply the diff. Latit. 66. 60 by the Sine of the Course 831, that Product 553446 divided by the Co sine of the Course 555, the Quotient 99. 7 is the departure required.

CASE 5.

Distance run and Departure given, to find the Course and diff. Latitude.

A Ship sails 120 leagues S Eastward, till her departure be 99. 72 leagues. I demand her Course and diff. Latitude.

1. Multiply the departure 99. 72 by 1000, that Product 9972000 divided by the distance run 120, gives 831 the Sine of 5 points for the Course required.

2. Multi-

2. Multiply the departure 99. 72 by the Co-sine of the Course 555, that Product 5534460 divided by the Sine of the Course 831, gives 66. 6 for the diff. Latit. required.

CASE 6.

Diff. Latitude and Departure given, to find the Course and distance run.

A Ship sails S Eward till her different Latitude be 66. 6 Leagues, and her departure be 99. 72 Leagues. I demand her Course and distance run.

1. Multiply the departure by 1000, that Product 9972000 divided by the diff. Latitude 66. 60, gives 1496 for the Tangent of the Course, which is 5 points.

2. Multiply the departure 99. 72 by 1000, that Product divided by the Sine of the Course 831, gives 120 Leagues for the distance required.

CHAP.

CHAP. XIV.

The Solution of all the Cases in Plain Sailing by Natural Arithmetick.

BEfore you proceed to the solution of any Plain Sailing Question, you must find whether difference of latitude or departure be the longest side in that Triangle: and this may be known from these following Rules.

1. If the Course be less than 4 points from the North or South, the diff. latitude is greater than the departure.

2. If the Course be more than 4 points from the North or South, the diff. latitude is less than the departure.

3. If the Course be just 4 points, the difference of latitude and departure are both equal: Which being known —-

If the diff. latitude be the lesser side, it must contain 1.0000. If the departure be less, it must contain 1.0000.

RULE.

1. Always divide 172 (with a competent Number of Cyphers annexed,) by the degrees and Decimal parts of a Degree contained in the Angle opposit to the lesser side.

2. From

2. From the Square of this Quotient, you must always subtract 3, and out of the remainer extract the Square root.

3. Subtract this Square root from the double of the Quotient ¼ of this remainer shall be the distance run.

4. Subtract the double of the distance run from the said Quotient, the remainer shall be the diff. latitude or departure according to that Scale whereby the lesser side contained 10000.

And thus you may find the three sides of this Nautical Triangle, the lesser side being assumed 1.0000.

But because in this way of solving plain sailing Questions, it is necessary that all the Sexagenary minutes in a Degree be reduced into Decimals. I shall here shew the way of reducing them.

If 60′ — 10000 — 1   If 60′ — 10000 — 15′
1.   15

6(1000)0(.166   6)15000 | 0 | 2500
44   3 | 0 |

And by this proportion was the following Table calculated, which shews how many decimal parts are contained in any number of minutes, the Degree or Integer being supposed to be divided into 10000 parts.

A

A Table shewing the Reduction of Minutes into Decimals, and the Contrary.

M.	Decimals	M.	Decimals	M.	Decimals	M.	Decimals
1	.0167	16	.2667	31	.5167	46	.7667
2	.0333	17	.2833	32	.5333	47	.7833
3	.0500	18	.3000	33	.5500	48	.8000
4	.0667	19	.3167	34	.5667	49	.8167
5	.0833	20	.3333	35	.5833	50	.8333
6	.1000	21	.3500	36	.6000	51	.8500
7	.1167	22	.3667	37	.6167	52	.8667
8	.1333	23	.3833	38	.6333	53	.8833
9	.1500	24	.4000	39	.6500	54	.9000
10	.1667	25	.4167	40	.6667	55	.9167
11	.1833	26	.4333	41	.6833	56	.9333
12	.2000	27	.4500	42	.7700	57	.9500
13	.2167	28	.4667	43	.7167	58	.9667
14	.2333	29	.4833	44	.7333	59	.9833
15	.2500	30	.5000	45	.7500	60	.10000

CASE 1.

Course and distance run given, to find the diff. Lat. and Departure.

A Ship sailes NEBE 146 Miles, I demand her diff. Latit. and departure.

By the 2d. of this Chap. it is evident that the diff. Latit. is less than the departure, and therefore must be assumed 1.000. Also by the forego-ing

Table you find .75 is the Decimal of 45'. Therefore

33°. 75 | 172.00000 | 5096 Quot. 5.096
305750 | 2 5.096
0100
10.192 Q. doub. 30576
45864
22.969216 | 4.792 Square root. 254800
16
| 696
| 639
Quot. squared 25.969216
subtract 3
949 | 8792
| 8541 remains 22.969216
9582 | 25116
| 19164
5952

from the Quotient doubled — 10.192
Subtract the Square root — 4.792
Remains — 5.400
of the remainer is the distance — 1.800
The distance doubled is — 3.600
Which subtracted from the Quotient — 5.096
The remainer is the departure — 1.496

Thus the three sides of this Triangle are found, whose lesser side is assumed 1.000. which being, known

known, we may by 4. 6. *Euc.* or by the Rule in Page 36. 37, find the responding proportional numbers for the sides of the Triangle required. For

If the supposititious distance 1. 8, require 14 Miles, the sppositirious diff. Latit. 1.000 shall require 81. 1 Miles, and the supposititious departure 1.496 shall require 121. 34 Miles.

CASE 2.

Course and diff. Latitude given to find the distance run and departure.

A Ship sails SEBS till her dist. Latit. be 14 Miles. I demand her distance run and departure.

Here the departure is the lesser side, and therefore must be assumed 1. 000. and the angle opposit to it is 33.75. Therefore divide 172. 0000 by 33.75. the Quotient is 5. 096, whose double will be 10.192 as afore, and the square thereof will be 25. 969216. Therefore

From the Quotient doubled	10.19
Subtract the square root	4.79
The remainer is	5.40
⅓ whereof is the distance as afore	1.80
The distance doubled makes	3.60
Which subtracted from the Quotient	5.09
The remainer is the diff. Latitude	1.49

Thus

Thus in these two Examples, the Course in the one, is equal to the Complement of the Course in the other, therefore (though the supposititious distance in both is 1.8) yet the diff. Latit. in the first Example is equal to the supposititious departure in the second, and the contrary. Then proceed as followeth,

If 1.496 — 144 — 1.800

1800

144

1.496 | 2592.00 | 173 Distance required.

1496

10960

10472

4880

4488

392

If 1.496 —— 144 —— 1.000

1.000

1.496 | 144.000 | 96 Depart. requir.

134.64

9360

8976

384

C A S E 3.

Course and departure given, to find the diff. Latitude and distance run.

A Ship sails SSW till her departure be 30 Miles. I demand her diff. Latitude and distance run.

The angle of the Course is less than 4 points, and being always opposit to the departure, the departure must be the lesser side, and consequently is accounted 1.000.

```
22.5 | 172.0000 | 7.644 Quot.                7.644
       1575     |    2                        7.644
       ----       ------                      -----
       1450       15.288 doubled              30576
       1350       ------                      30576
       ----                                   45864
       1000                                   53508
        100                                   ------
       ----     Square of the Quot.  58.430736
       1000     from which subtract  -3
 . . . .                             ---------
55.430736 | 7.445 Remainer is ------ 55.430736
49                                   ---------
---
144  | 643
     | 576
1484 | 6703
     | 5936
----
1488 | 77136
     | 74420
     -----
      2716
```

From the double Quotient — 15.288
Subtract the square root — 7.445
Remainder is — 7.843
whereof is the suppositious distance — [illegible]

The double distance is — 5.228
Which subtract from the Quotient — 7.644

The remainer is the supposit. diff. Lat. — 2.416

If 1.000 — 50 — 2.614
50

130.700 Dist. 130. 7 Miles.

If 1.000 — 50 — 2.416
50

120.800 diff. Latit. 120.8 Miles.

C A S E. 4.

Distance run and diff. Latit. given, to find the Course and Departure.

A Ship sails 120 Miles, till her diff. Latit. be 81 Miles; I demand her departure, and Angle of the Course?

 These

These three following Cases do depend upon 47. 1. Euc. where it is demonstrated that in a Right-angled plain Triangle, the square of the Hypothenusal is equal to the square of the Base and square of the Perpendicular added together.

Therefore square the distance 120, which is 14400, also square the diff. Latit. 81. which is 6561. then

From the square of the distance	14400
Subtract the square of the diff. Latit.	6561
The remainer is	7839

The square root of which is the departure.

```
7839.00 | 88.5 Departure in Miles.
64
168   1439
      1344
1765  9500
      8825
       675
```

To find the Course.

To the distance run add the departure (if the departure be greater than the diff. Latit.) or the diff. Latit. (if that be greater than the departure.)

The distance run 120, to which add the departure 44. 25, the sum is 164. 25. Then say,

If

164.25 — 81 — 88 is to the Comp. of the Course

86			
688			
164.25	6966.0000	42.41	
	65700		
	39600		
	32850		
	67500		
	65700		
	18000		
	16425		
	1575		

In the Table for reducing Decimals into Minutes, seek for 41, and the responding number shews about 25 Minutes; so that the Compleat angle of the Course is 42°. 25'. therefore the true angle of the Course is 47°. 35'.

CASE 5.

Distance run and Departure given, to find the diff. Latitude and Course.

A Ship sails 146 Miles till her departure be 108 Miles, I demand her diff. Latitude and Course.

From the Square of the distance, subtract the Square of the departure, the Square root extracted out of the remainer gives the diff. Latitude.

9652 (98 diff. Latit.		108	146
81		108	146
188	1552	864	876
	1504	1080	584
	48	11664	146
		From	21316
		take	11664
			9652

Or thus, to find the diff. Latitude.

Multiply the sum of the distance run and Departure by their diff. the Square root of that Product shall be the diff. Latit.

9652 (98 diff. Lat.			146
81			108
188	1552	Sum	254
	1504	diff.	38
	48		2032
			762
		Prod.	9652

To

To find the Course.

To the distance run 146
add ⅓ the departure (being the greatest side) 49

Sum is 195
As that sum 195 — 98 diff. Lat. — 86 to Co. S.
Course. 86

$$
\begin{array}{r|l|l}
 & 98 & \\
 & 784 & 43.22 \text{ or } 13 \text{ Min.} \\
195 & 8428.36 & \\
 & 780 & 100 \\
 & .628 & \\
 & 585 & \\
 & .430 & \\
 & 390 & \\
 & .400 & \\
 & 390 & \\
 & 10 & \\
\end{array}
$$

Here the Comp. of the Course is 43°. 13′. which subtracted from 90°. 00′. the remainer 46°. 47′. is the Angle of the Course required.

CASE

CASE 6.

Diff. Latitude and Departure given, to find the distance run and Course.

A Ship sails till her diff. Latitude be 86 Miles, and her Departure 104 Miles. I demand her distance run and Course.

To the Square of the diff. Latit. add the Square of the Departure, the Square root of that sum shall be the distance run.

```
                  86                         104
                  86                         104
                 ----                        ----
                 516                         416
                 688                        1040
                 ----                        ----
Diff. Latit. squared 7396   depart. squared 10816
      . . .          134.9  dist.            7396
     18212 |                                 -----
     1     |                          sum   18212
    ------
 23 | 82
    | 69
    ------
264 | 1312
    | 1056
    ------
2689 | 256.00
     | 24201
     -------
       1399
```

To find the Angle of the Course.

To the distance run 134.9 and : the Departure, 54. the sum is 188. 9, then say

As 188,9 is to diff. Latit. 86, so is 86 to comp. Angle.

86

688

188.9 | 7396.000 | 39.15 Deg. or 39°. 9'.
5667

1729
1700

189
188

10010
9445

565

Subtract 39°. 9'. from 90°. 00'. the remainer 50°. 51'. is the Angle of the Course.

The

The Solution of Oblique Triangles by Natural Arithmetick.

CASE 1. Fig. 41.

Two sides with an Angle opposite of to one them, to find the other Parts.

A Ship at A observes an Island at B, bearing ENE, she runs away NEBN 8 Miles to C. and then found the Island at B to be 6 Miles from her. I demand the Course from C to B and the distance between A and B.

From C let fall the Perpendicular CD, so have you reduced the oblique angled Plain Triangle into two right angled Plain Triangles, *viz.* ACD, called the first, and BCD the second Triangle. In the first Triangle ACD, we have given the Hyp. AC, and the Angle at A, to find the Base AD, and the Perpend. DC, which may be done by the following Table.

A Table shewing the distance run, diff. Latit. or Dep. from every Point, 1¼ or ½ Point of the Compass.

Angle of the Course in Degree and Decimal parts.	Distance.	Diff. Lat. or Departure
2. 8125	20. 39	20. 37
5. 625	10. 21	10. 15
8. 4375	6. 82	6. 74
11. 25	5. 13	5. 03
14. 0625	4. 14	3. 87
16. 875	3. 41	3. 37
19. 6875	2. 97	2. 797
22. 5	2. 614	2. 416
25. 3125	2. 340	2. 115
28. 125	2. 122	1. 871
30. 9373	1. 945	1. 669
33. 75	1. 800	1. 496
36. 5625	1. 678	1. 348
39. 375	1. 576	1. 218
42. 1875	1. 462	1. 153
45.	1. 000	1. 000

In this first Case of Obilques, seeing the Angle A is 33. 75. you find against it in the Column of distance stands 1. 8. and because the angle GAD is less than the angle ACD, therefore the side AD shall be greater than the side CD. But CD being the least side in the Triangle ADC, must be assumed 1. 00, &c. and then the side AD will be 1. 496. thus the three supposititious sides are known. Therefore say,

If

If AC 1.8 — AC 8. what shall AD. 1.496.

8 AC

1.8) 11.968(66

108

116

108

88

72

If AC 1.8 — AC 8 — DC 1.000.

8

1.8)8.000(444

72

80

72

80

72

DC

8

To find the side BD we have given the Hyp. C[B] and Perpend. CD. therefore by 47.1 Eu. fro[m] the Square of CB subtract the Square of CD th[e] Square root of the remainer is the length of th[e] BD. which added to AD gives AB. As thus,

36.0000 DC 4141 17.76
19.7136 BD | 4.44 6

162864 | 402 1776 36
16 | 6.64 AD 1776
1776
803 | 2864 10.68 AB
| 2406 19.7136

A 455

To find the angle CBD, add the Hypothenusal CB and ½ of CD (which is the greater Leg) together: Then say,

CB.6
As 8.22. to BD 4.03 So is 86 ½ CD 2.22
86
Sum 8.22
2418
3224
D.
8.22 | 346.58 | 42.16 or 42°. 10′
3288 |
100
1778
1644
1340
822
5180

Hence

Hence it is evident, that if you subtract 42°. 10′ from 90°. the remainer is 47°. 50′ for the angle at B.

CASE 2. FIG. 41.

Two sides with their contained Angle given, to find the other Angles and the third side.

A Ship at B observes an Island at A bearing West 9.8 Miles from her, she sails NWBW 76 Miles to C, I demand her bearing and distance from the Island.

Draw AB for an East or West line, set 9.8 Miles from B to A, then draw a NWBW line as BC, upon which set up 6 Miles from B to C, lastly draw the line AC.

Let fall the Perpend. CD, so shall CBD be the first Triangle, and ACD the second. In the Triangle BCD, CD is the lesser side, and must be assumed 1.000. Also in the preceeding Table CB is 1.8, and consequently by the same Table BD must be 1.496. Therefore say,

BC	BC	DC	DC
If 1.8	7.6	1.000	4.222.

```
        1.000
      ---------
1.8 | 7.6000 | 4.222 DC.
    | 72     |
      ------
        40
        36
        --
         40
         36
         --
          40
          36
          --
           4
```

BC	BC	BD	BD.
If 1.8	7.6	1.496	5.316

```
               7.6
            --------
              8976
            10472
           ---------
1.8 | 11.3696 | 6.316
    | 108     |
     ---------
         56
         54
         29
         18
         116
         108
         ---
           8
```

Q

Which

Which subtracted from BA9.8 the remainer 3.48[4] is DA.then in the second Triangle ADC we ha[ve] given AD. and DC. to find the Hypothenusal AC thus,

. . . .	DA-3.484 DC-4.22[2]
29.963540 | 5.473 AC.	3.484 4.22[2]
25	
104|496	13936 844[4]
|416	27872 8444
	13936 8444
1087|8035	10452 16888
|7609	
	12.138256 17.8252[84]
10943|42640	12.13825[6]
|32829	
	29.96354[0]
.9811	

The angle may be found as in Case 1. of Obliques.

CASE 3. Fig. 42.

Three Sides given, to find the three Angles.

A Ship at A observes two Islands, the one at B bearing East 9.9 Miles from her; the other at C 7.6 Miles distant between the East and North, but the two Islands were 6.6 Miles asunder. I demand their bearing and the Course from A to C.

Draw

Draw the East line AB, upon which set 9.9 Miles from A to B, take 7.6 Miles in your Compasses, and with one foot in A strike the Arch C, then take 6.6 Miles in your Compasses, and from B cross the arch C in C. Draw the lines ACD and BC. Lastly from C with the distance BC strike the arch DBGF to cut AB in G, and AC in F, so shall AG be the alternate Base, AD shall be the sum, and AF the diff. of the two sides AC. CB.

To find the alternate Base, say,

As the true Base AB 9.9.
Is to Sum of the two sides AC.CB 14.2.
So is their diff. AF 1 0.
To the alternate Base AG 1.4.

Which subtracted from AB. the remainer is GB 8.5 the ½ whereof is EB 4.25. equal to EG. then to EG 4.25 add AG 1.4, the sum is AE 5.65. thus have we two right angled plain Triangles, viz. ACE. CEB. in either of which we have given the Hypothenusal and Base to find the angles, which you may effect by Case fourth and fifth of this Chapter.

CHAP. XV.

Of Currents.

I find none amongst those who have published any thing of Navigation, except in Mr. *Norwood*; where the business of Currents is tolerably handled. And he himself hath omitted to say any thing Prefatory in order to the compleat understanding thereof. Upon which account I thought the ensuing Precognita's might be serviceable to such as are curious.

First, One and the same Moveable may be agitated by many different and opposite motions at the same time. For if a Man be Walking on Board of a Ship, *viz.* directly East, while the same Ship is carried Westward, he admits of two motions; add to these two, the motion of the Sea it self round the Earth, then it is evident, that if the Sea, the Ship, and the Man do all move together, the Man admits of three motions.

Secondly, When any Moveable admits of many motions, two things are principally to be considered.

1. The *terminus à quo*, or the beginning of the motion; the *terminus ad quem*, or the end or cessation thereof.

2. The

2. The line or way which this moveable describes.

FIG. 43.

As to the *terminus à quo*, and *terminus ad quem*, let us suppose any moveable to be carried from A to B, and in the mean time let the whole plain (upon which that motion is performed) be supposed to move directly contrary to C: If then the moveable body move with the same celerity towards B, as the whole plain AB is moved towards C, that moveable shall always remain in the same place A. If the moveable body in passing from A to B, move more slowly than the whole plain AB doth towards C, then it shall (as Seamen usually call it) lose ground, or be carried towards C. But if it moves more swiftly towards B, than the whole plane AB doth towards C, then it gains ground, and is carried towards B; and always by the same proportion of celerity, by which the motion towards B, exceeds the motion towards C, or is exceeded by it. Lastly, if a moveable be moved towards B, and at the same time the plain AB, upon which it moves, be carried also towards B; it is manifest, the moveable in passing from A to B, is carried more swiftly towards B, than by its simple motion could be effected.

As to the line which any moveable describes, when it is affected with diverse motions, it is sometimes a right line, sometimes the circumference of a Circle, sometimes a particular Section of a Cone, sometimes a Spiral, *&c.* and there is

no kind of lines which can be aſſigned, but may be deſcribed by certain compound motions.

FIG. 44.

Let ABCD be a Parallelogram: Upon the ſide AB let a Fly be ſuppoſed to move equally from A to B: And at the ſame time, let the ſide AB be ſuppoſed to move equally (with the Fly upon it) between the lines AB.DC. in ſuch manner that the ſide AB in its motion towards DC ſhall always be parallel to the ſide DC. I ſay, that the Fly by this twofold motion deſcribes the line AD.

Firſt, Let us ſuppoſe the motion of the Fly and that of the plain to be equal: That is, for every Inch the Fly moves from A towards B, let the plain AB be ſuppoſed to move an Inch towards CD, and that theſe two motions be performed in the ſame time: Then it follows, that while the Fly is moving from A to B, the plain AB is moved from AB to EF, and the point B is moved to F. Therefore the Oblique line AF is the line which the Fly deſcribes by that motion.

Again: Let us ſuppoſe the Fly to move more ſwiftly than the plain; that is, in the ſame time that the Fly moves from A to I, let the plain AI be moved to GH. Then it appears that the motion of the Fly is performed upon the line AH. Laſtly, Let us ſuppoſe the plain to move more ſwiftly than the Fly; that is, in the ſame time that the Fly moves from A to B, the plain AB is moved to DC, and therefore the line of the Flies compound motion is AD. And here note, That the

the point A is called the *Terminus à quo*, and the point D, the *Terminus ad quem*.

This may suffice for an Introduction to the Explication of the Nature of Currents; and from hence it is easie to conceive, that a Ship sailing where there is a Current, hath a compound motion arising of two different Principles, *viz.* that of the Current, and that of the Ship; and from these two proceeds a third, which is the Ship's compound motion. These three different kinds may for distinction be thus called.

The first may be called, the way or simple motion of the Current. The second, the way or simple motion of the Ship; and the third may be called the line of the Ship's true motion.

Whence observe, That if the motion of the Current, and that of the Ship be both Rectilinear (as we suppose them to be in all the following Problems) the third also will be a right line, as may appear from *Fig.* 44. In which Figure you may note, That if the line AB represents the Ships simple motion, and the line BD the simple motion of the Current, and the line AD the Ships compound motion, then the angle BAD is called the angle of Deflexion, and the angle ADB the angle of Reflexion.

PROB. I. Fig. 43.

Admit a Current runs East 6 Miles an hour, and a Ship sails West directly against it 6 Miles an hour. I demand her compound motion.

Let the Current run directly East from A to B, and the Ship directly West from B to A, it is evident, that the Ship makes no way but stands still in the same place: For so much as she is forced forwards by the Wind, so much she is driven backward by the motion of the Current. Therefore,

From the Ships simple motion	6	Miles.
Subtract the motion of the Current	6	
The remainer is the Ships motion	0	

PROB. 2. Fig. 43.

Admit a Current runs East four Miles an hour, and a Ship sails West directly against 6 Miles an hour. I demand her compound motion.

It is evident that if the Ships motion exceeds the motion of the Current, the Ship advanceth nearer towards B. Therefore

From the Ships simple motion	6	Miles.
Subtr. the simple motion of the Current	4	
Remains the Ships compound motion	2	

PROB. 3 Fig. 43.

A Current sets West 8 Miles an hour, and a Ship sails East directly against it 5 Miles an hour. I demand her compound motion.

Her

Here it is evident that because the Current moves faster than the Ship, the Current must force the Ship backwards, tho' by the Log line she appears to gain ground. Therefore

From the Currents simple motion--8		
Subtract the Ships simple motion---5		Miles.
Remains the Ships comp. motion—3		

And thus the Ship falls a Stern 3 Miles every hour.

PROB. 4. Fig. 43.

A Ship sails East 4 Miles an hour, upon a Current, which sets East 5 Miles an hour. I demand her compound motion.

Here it is evident, that seeing the motion of the Ship, and that of the Current are both one way, therefore the Ships motion is accelerated by that of the Currents. So that you must

Add the Currents motion ——————5		
To the Ships simple motion————4		Miles.
That Sum is the Ships comp. motion----9		

PROB. 5. Fig. 44.

A Ship sails South 3 Miles an hour, where there is a Current running East 5 Miles an hour. I demand the Ships compound motion, and which way.

Let

Let AB represent the Ships simple motion, BD the Currents simple motion, and AD the Ships compound motion. Then in the Triangle ABD we have given AB 3, and BD 5, to find the angle of Deflexion BAD, and the Ships compound motion AD.

As the Ships simple motion AB. 3- —— 047712
Is to the Currents simple motion BD.5 —— 069897
So is Radius —— —— —— —— 90.00 – 1000000

To Tangent angle Deflex. BAD.-59.02 – 1022185

As sine angle Deflex. BAD— -59.02— -993321
Is to the Currents motion BD —— 5 —— 069897
So is Radius —— —— —— —— 90.00-1000000

To Ships compound motion BD- -5.8 Mil. 076576

Hence it appears, that the Ships Course is SEBE 2°. 47′ E, and her horary motion is 5.$\frac{8}{10}$ Miles.

PROB. 6. Fig. 44.

A Ship sails East 4 days together, by Log. 480 Miles, where there is a Current setting all this while to the Southward 2½ Miles each hour. I demand her angle of Deflexion and compound motion

To find how many Miles the Current hath run in 4 days, multiply 24 (the number of hours in one day) by 2½ Miles (the Currents horary motion) the Product 60 is the number of Miles the Current sets in 24 hours. This 60 multiplyed by

4

4 (the number of days given) produceth 240 Miles for the Currents motion in 4 days; then say,

As the Ships ſimple motion BD 480—268124
Is to the Curr. ſimple motion BA 240—238021
So is Radius- - ——— ——— -90.0 -1000000

To tangent angle Reflex. BDA—26.33---969897

Hence the Ships Courſe is ESE 4°. 3′ Southward.

As ſine angle Reflexion BDA 26.33—992085
Is to Ships ſimple motion BD 480 Mil.-268124
So is Radius ——— ——— —— 90.00 1000000

To Ships compound motion AD 576 Mil.-276039

PROB. 7. Fig. 44.

A Ship ſails in 8 hours from A ſome certain Cape towards B bearing South 18 Miles by Log. in a Current ſetting to the Eaſtward, and then obſerving the ſame Cape ſhe finds it to bear WNW. I demand how faſt the Current ſets, and the Ships true diſtance run.

Let A repreſent the Cape, BD the Ships drift to the Eaſtward: The Ship at D obſerves the Cape A to bear WNW, then in the Triangle ABD we have given AB 48 Miles, and the angle ADB 22°. 30′.

To

To find the motion of the Current BD.

As ſine angle Reflex. ADB 22°. 30′ —— 95828
Is to Ships ſimple motion AB 18 Miles --- 12552
So is ſine angle Deflex. BAD 67.30 —— 99656

1122088

To Currents ſimple motion BD 43.6 Mil. - 16380

Hence it appears, that if the Currents ſimple motion be 43.6 Miles in 8 hours, the horary rate or drift thereof muſt be 5.45 Miles.

To find the Ships Compound motion AD.

As ſine Angle Reflex. ADB 22°. 30′ -- 958283
Is to Ships ſimple motion AB 18 Miles -- 125527
So his Radius ——— ———— -90.00 — 1000000

To the Ships comp. motion AD 47 Miles — 167244

PROB. 8. Fig. 45.

Admit AB.CD repreſent the ſides of a River, let A repreſent one place on this ſide, and C another place on the farther ſide, let their diſtance be 96 Poles, Yards, *&c.* let the Courſe from A to C be NE ½ E, and let the Current in this River drive directly Eaſt, 3½ Miles every hour; then if a Boat row from A towards C after the rate of 5½ Miles an hour; I demand upon what point of the Com-

Compass the Boat shall row, how fast, and in what time to go directly over.

The sides of the Triangle ACD are Suppositions: Therefore, first, set the Currents simple motion 3 ' Miles from C to D. From C with the Chord of 60°. strike the arch EF, then because SW¼W (the opposite point to the Course given) is 11½ points, or 129°. 23', set 129°. 23' from F to E, and draw the line CEA. Lastly, with 5¼ Miles set one foot in D, and with the other cross the line CA in A and draw DA. Lastly, From A draw AB parallel to CD, so shall ACD be the angle of Deflexion, ADC the angle of Reflexion, and the angle CAD may be called the angle of Incidence. Also CD is the Currents simple motion, and AD the motion of the Boat.

1. To find the angle of Incidence CAD.

As the Boats simple motion AD 5¼	074036
Is to the sine of Reflex. ACD 129.23	988813
So is the Curr. simple mot. CD 3¼	054406
	1043219
To the sine of Incid. angle CAD 29.28	969183

Which added to 4½ points, or 50°. 37' makes 80°. 05'. Therefore the Course from A to D is EBN 1°. 20' Eastward.

To

To find the Diſtance AD.

From the Quadrant IK 90°. 00′, ſubtract th angle IAG 80°. 05′ the remainer 09°. 55′ is th angle GAK, which by 27. 1 *Euc.* is equal to th angle of Reflex. ADC.

As ſine angle Reflexion ADC 9°. 55′——9236
Is to diſtance 96 Poles, &c. ——————1982
So is ſine of ang. Deflex. ACD 129.23——9888

1187

To Boats ſimple motion AD 431 Poles——26343

To find the time required.

Seeing that 320 Poles make a Mile, and the Boats horary motion is $5\frac{1}{2}$ Miles, therefore 320 multiplyed by 5.5. produceth 1760 for the number of Poles which the Boat runs every hour. Therefore

As the Boats ſimp. hor. motion 1760——324551
Is to 60 (the minutes in one hour) ——177815
So is the ſimple motion before found 431——263433

441248

To the time required in minutes 14.7——116697

PROB. 9.

PROB. 9.

To find where there is a Current at Sea, which way it ſets, and how faſt.

This may moſt conveniently be done by comparing the reckoning outwards, with the reckoning homewards, after this manner.

Admit a Ship ſail from a certain Port (either upon one or upon ſeveral Rhumbs) till ſhe arrives at a ſecond, and there find by her dead reckoning that ſhe is more Southerly than the Port from whence ſhe departed by 432 Miles, and more Weſterly by 234 Miles. But by her dead reckoning homeward, when ſhe arrived at the firſt Port ſhe found ſhe was 432 Miles to the Northward of the ſecond, and to the Eaſtward thereof 345 Miles: Then let us ſuppoſe ſhe ſailed from the firſt Port to the ſecond in three days time, and from the ſecond to the firſt in 5 days, I demand which way the Current ſets and how faſt.

Becauſe the Eaſtward diſtance homewards did exceed the Weſtward diſtance outwards, ſubtract the one from the other, namely 234 from 345 the remainer 111 Miles, is the motion of the Current Weſtward.

Hence it appears, the Current ſets to the Weſtward 111 Miles in 8 days time, which is almoſt 14 Miles a day.

CHAP.

CHAP. XIV.

A Collection of sundry choice Problems in Plain Sailing.

PROB. 1. Fig. 47.

THERE are two Ships under the same Meridian, the first in the N°. Latitude of 50°. 00', the second in an unknown N°. Latitude; when the first Ship had sailed 88 Leagues between the South and West, and the second 56 Leagues between the North and West; they both meet, their Course being 6 points asunder, I demand each Ships Course, and in what Latitude they did meet.

GEOMETRICALLY.

Draw the line BA at pleasure: Make the angle BAC 67°. 30', set 88 Leagues from A to B, and 56 Leagues from A to C, draw the line BC, which shall represent the Meridian from whence both the Ships departed: From A draw AD perpend. to BC. so shall BD be the first Ships differ. Latit. DC the second Ships differ. Latit. and AD shall be the departure, common to them both; also the angle ABD shall be the first Ships Course, and ACD the second.

LOGA-

LOGARITHMICALLY.

As the sum of the 2 sides AB.AC	144	215836
Is to their diff.	32	150515
So t. ½ sum ang. B and C	56. 15	1017510
		1168025
To t. ½ their diff. 18°. 24′		952189

Which added to the ½ Sum 56°. 15′ makes the greater of the two unknown angles, viz. ACD 74°. 39′, and subtracted from the ½ Sum, leaves the angle ABC 37°. 51′.

As Radius sine angle ADB 90°. 00′	1000000
Is to distance run AB 88 leagues	194448
So is sine angle BAD 52°. 09′	989741
To diff. Latitude BD 69.5 leagues	184189

Thus it appears the first Ships Course is SWBS 4°. 6′ W.

As Radius sine angle ADC 90°. 00′	1000000
Is to distance run AC 56 leagues	174818
So is sine of the Course, ang. CAD 15°. 21′	942277
To second Ships diff. latit. CD 14.8 leag.	117095

Hence it appears by 1. and 2. Rule 1. Page 179. that the Ship is in the N°. Latitude of 46°. 32′. and that the second Ships Course is WBN 4°. 6′ Northwards.

Note, The Triangles ADB, ADC are right angled at D; therefore if the angle ABD 37°. 51′ be

be known, subtract it from 90°. the remainer i
the angle BAD 52°. 09′: Also ACD 74°. 39′ sub-
tracted from 90°. 00′. the remainer is CAD
15°. 21′.

PROB. 2. Fig. 48.

A Ship sails from the N°. Latit. of 53°. 00′ upon some Rhumb between the South and the West, till her diff. latit. be 25 leagues, and her distance run and departure be together 84 leagues. I demand them severally and the Course she sailed.

GEOMETRICALLY.

Draw the line AB, upon which set the diff. latit. from A to B, draw BC perpend. to AB, and set 84 leagues from B to C, then draw the line AC, which you must bisect by the line DE, then draw the line AD, which shall be equal to the line DC, so shall BD be the departure, and AD the required distance run.

LOGARITHMICALLY.

As the side AB 25 leagues	139794
Is to Radius sine of 90°. 00	1000000
So is the side BC 84 leagues	192427
To tangent angle BAC 73°. 26	1052633

Which subtracted from 90°. 00′, the remainer is the angle BCA 16°. 34′, but the angle BCA is equal to the angle CAD. because the two sides

AD.

AD. DC are equal, therefore from the angle BAC 73°. 26′ subtract the angle DAC 16°. 34′. the remainer is the angle BAD 56°. 52′, or Ships Course from A to D, *viz.* SWBW 0°. 37′ W. which also subtracted from 90°. the remainer is the angle ADB, *viz.* 33°. 8′.

As sine angle ADB 33°. 08′	973766
Is to diff. Latitude AB 25 leagues	139794
So is Radius sine of 90°. 00′	1000000
To the distance required AD 45.75 leag.	166028

Which subtracted from 84, the remainer is 38. 25 leagues the departure required.

PROB. 3. Fig. 49.

A Ship sails upon some Rhumb between the North and East, so that for every 86 Miles she departs from her first Meridian 58 Miles, the latitude she came from being 48°. 30′. I demand the Course and distance she must sail to come into the lat. of 50°.

GEOMETRICALLY.

Project the Triangle ABC, making BC 58 Miles and AC 86 Miles, then by 1. 3. Rule in Page 180. find the diff. latit. between 50°. 00′ and 48°. 30′, which is 1°. 30′ or 90 Miles. Set 90 Miles from A to D, draw DE parallel to BC, and continue the line AC to cut DE in E, so shall AE be the distance, and the angle DAE the Course required.

LOGARITHMICALLY.

As the distance run AC 86 Miles — 19344
Is to Radius sine 90°. 00′ — 100000
So is the departure BC 58 Miles — 17634

To sine of the Course angle BAC 42°. 25′ — 98284

Therefore the Course is NE 2°. 35′ Northward.
As sine of the angle DE 47°. 35′ — 98682
Is to diff. latit. AD 90 Miles — 19542
So is Radius sine of 90°. 00′ — 100000

To the distance required AE 122 Miles — 20862

PROB. 4. Fig. 50.

A Pilot sailing towards the East hath forgot his Course, yet thus much he knows, that if he had sailed upon his true Course 108 leagues, he should have raised the Pole 2°. 51′ and have been as much more distant from the Meridian than now he is, and also should have been 57 Minutes more Northerly, I demand the Course, distance and departure.

GEOMETRICALLY.

Finish the Triangle ABC, in which let the diff. latit. AB be 57 leagues, and the distance run AC 108 leagues: Then set 19 (the leagues in 57 min.) from B to D, draw DE parallel to BC. Bisect DC in F, and from F draw FE parallel to AB. Lastly,

lastly draw the line AE, so shall AD be the Ship diff. latit. DE the departure and AE the Ships distance run required.

LOGARITHMICALLY.

As the distance run AC 108 leagues	203342
Is to Radius sine of 90°. 00'	1000000
So is the diff. latit. AB 57 leagues	175587
To sine of the angle ACD 31. 51.	972245

Which subtracted from 90°. 00'. leaves the angle CAD 58°. 09', therefore the Ships Course is NEBE 1°. 54' Eastward.

As Radius sine of 90°. 00	1000000
Is to distance run AC 108 leagues	203342
So is sine of the Course, angle DAC 58.09	992912
To the Ships departure BC 91.74 leagues	196254

The $\frac{1}{2}$ of BC 91.74 is 45.87. equal to DE, then reduce 57 minutes into leagues, *viz.* 19. and set 19 leagues from D to B, so shall AB be 38 leagues. Then in the triangle ABE say,

As AB 38 leagues	157978
Is to Radius	1000000
So is BC 45.87 leagues	166152
To t. of the Course BAC 50°. 22'	1008174

As the sine angle BAC 50.22 ——— 988651
Is to departure BC 45.87 leagues ——— 166152
So is Radius sine of 90.00 — — — 1000000

To the distance required AC 60 leagues -- 177495

Therefore the Course from A to C is NE 50. 22′ Eastward.

PROB. 5. Fig. 51.

Two Ships, the one sailing between the South and East 94 leagues; the other between the South and West 68 leagues, their Courses being 5 points asunder; then if the Eastermost Ships diff. latitude be 36 leagues more than the Westermost Ships diff. latit. I demand each Ships Course, their bearing and distance asunder.

GEOMETRICALLY.

Draw the line BA. make the angle BAC 56°. 15′. set 68 leagues from A to B, and 94 leagues from A to C, and draw BC. With 36 Leagues in your Compass, set one foot in C and strike the Arch E, and from B through the highest point in the Arch E, draw the line BE, which shall be an East or West line, also draw EC and AD perpend. to BE, so shall CE be a North, and AD a South line, the angle BAD shall be the Westermost Ships Course, and DAC the Eastermost: Lastly the angle ABC shall be the bearing, and BC the distance between the two Ships.

LO-

LOGARITHMICALLY.

As the Sum of the 2 sides AB.AC 162--220951
Is to their difference 26 leagues ---- ---141497
So is t. ½ Sum ang. B and C 61°.52'. --- 1027189

1168686

To t. ½ their diff. 16°. 42' --- ---- 947735

Which added to the ½ Sum, makes the angle ABC 78°.34' and subtracted from it, leaves the angle ACB 45°. 10'.

As sine of the angle ABC 78°. 34'------999129
Is to distance run AC 94 leagues ------ 197312
So is the sine of the angle BAC 56° 15'--991984

1189296

To the distance BC 79. 7 leagues --------- 190167

As the side BC 79. 7 leagues- -------- 190167
Is to Radius sine angle BEC 90°. 00' ---- 1000000
So is diff. latit. CE 36 leagues - ------ --155630

To sine angle CBE 26°. 50' --- -965463
Therefore the Course from B to C is ESE 4°. 20' S°.

But the angle CBE 26°. 50' subtracted from the angle ABC 78°. 34' leaves the angle ABD 51°. 44'. this subtracted from 90°. the remainer is BAD 38.16. Therefore the Course from A to B is SWBS 4°. 31' W. Lastly, subtract BAD 38°. 16' from BAC 56°. 15', the remainer is DAC 17°. 59',

59', and consequently the Eastermost Ships Course is SBE 6°. 44' Eastward.

PROB. 6. Fig. 52.

There are three Ships of equal distance from one Port, and bound for the same place: The Eastermost is distant from the middlemost 96 leagues, and bears SEBE, the middlemost is distant from the Eastermost 80 leagues, and bears SW from her: I demand each Ships Course to the Port, and how far they are distant from it.

GEOMETRICALLY.

Draw an obscure line as BE to represent a South line: Draw the SW line B C, upon which set 80 leagues from B to C: draw the SEBE line BA, upon which set 96 leagues from B to A: Then draw CA, which shews the bearing and distance between the first and third Ships.

Through the three points ABC strike a Circle, whose Center D represents the Port required: Lastly, draw the Semidiameters DA, DB, DC which shall be the distance of each Ship from the Port.

LOGARITHMICALLY.

As the Sum of the 2 sides BA.BC 176 l.--	224551
Is to their difference 16 leagues--	120412
So is t. ½ Sum of the ang. BAC.BCA 39.22	991404
	1110816
To t. ½ their difference 4°. 16′	887265

Which added to the ½ Sum makes the angle BCA 43°. 38′ and subtracted from it leaves the angle BAC 35°. 06′. Therefore the Course from C to A is EBN 9°. 53′ E.

As sine of the angle BCA 43°. 38	983887
Is to the side AB 96 leagues	198227
So is sine angle ABC 101°. 15′	999157
	1197384
To the side CA 136 leagues	213497

Which is the distance between the two Ships A and C.

By 20. 3. *Eucl.* the angle ADC is double to the angle ABC, which is 101°. 15′, therefore the angle ADC is 202°. 30′, which subtracted from 360°. 00′, the remainder is the angle CDA, *viz.* 157°. 30′, but because the sides DA. DC are equal, therefore the angles DAC. DCA are equal. Therefore subtract 157°. 30′ from 180°. 00′, the remainder is 22°. 30′, ½ whereof is the angle CAD 11°. 15′, or ACD.

As

As sine of the inter. ang. CDA 157°.30 — 958284
Is to the distance CA 136 leagues —— 213497
So is sine angle DAC 11°. 15 —— 929023

1142520

To the side DC 69.56 leagues —— 184236
Which is the distance of each Ship from the Port.

To find the Course from C to D, the angle BCD is 43°. 38′ which added to 11°. 15′, the Sum is 54°. 57′ from the NE line Eastward, therefore the Course from C to D is ESE 1°. 22′ E.

PROB. 7. Fig. 53.

Two Ships sail from two several Ports being both in one Parallel, and 90 leagues asunder; the Westermost Ship sails NEBE, the Eastermost Ship sails upon some point between the North and West, and then they meet: If the distance run of both these Ships be together 136 leagues, I demand them severally and the Eastermost Ships Course.

GEOMETRICALLY.

Draw AB, set 136 leagues from A to B, make the angle ABC 33°. 45′, and set 90 leagues from B to C, then draw the line AC: Bisect the line AC in D by the line DE and draw CE, so shall AE, EC be equal to each other: Therefore BE, EC shall be equal to AB: also BE shall be the Westermost Ship's distance, the angle BCE the Eastermost Ships Course. Lastly BC is the parallel they departed from.

LO-

LOGARITHMICALLY.

As the Sum of the two sides AB.BC. 226 —	235410
Is to their difference 46 leagues —	166275
So is t. ½ Sum ang. BAC.BCA 73°. 07′ —	1051783
	1218058
To t. ½ their diff. 33°. 51′ —	982648

Which added to the ½ Sum 73°. 07′ makes the angle ACB 106°. 58′. and subtracted from it leaves BAC 39°. 16′. But the angles EAC, ECA are equal, because of the equal sides AE.EC, therefore subtract ACE 39°. 16′ from ACB 106°. 58′, the remainer ECB is 67°. 42′ Lastly add the angles EBC 33°. 45′, and ECB 67°. 42′, together their Sum will be 101°. 27′, which subtracted from 180°. 00, the remainer is the angle BEC 78°. 33′.

As sine angle BEC 78°. 33′ —	999127
Is to the Parallel distance BC 90 leagues —	195424
So is the sine angle EBC 33.45 —	974473
	1169897
To the distance required EC 51 leagues —	170770

Which subtracted from 136 or AB, the remainer is BE 85 leagues for the Westermost Ships distance run, and the angle ECB is the Eastermost Ships Course, viz. NNW 0°. 12′ N.

PROB.

PROB. 8. Fig. 54.

A Ship sails between the South and West, her distance run be 86 leagues more than her diff. Latit. and 54 leagues more than her departure, I demand her Course, distance run and departure.

GEOMETRICALLY.

Draw the line AD, set 86 leagues from A to B and from B to C, and 54 leagues from C to upon C, erect the perpend. CE. Bisect AD in O from O strike the Semicircle to cut the perpend. CE in E, so shall CE be an Auxiliary line. Then draw the line EH, set 86 leagues from E to F, and set CE from F to G, and from E strike the arch GI. Also set 54 leagues from G to H, and from H strike the arch FI. Lastly draw the lines EI, HI, so shall EI be the departure, HI the diff. of Latit. and EH the Ships distance run.

ARITHMETICALLY.

Multiply 172 (the double of 86) by 54, out of the product 9288 extract the square root, which here is 96, so shall this square root be the length of the line CE: Therefore 86. 96. 54 added together, make EH, the distance run 236. From which subtract 86, the remainder 150 is HI the diff. latitude, and 54 subtracted from 236, gives EI 182 for the departure. The Course may be found by Case 6. of plain sailing.

PROB.

PROB. 9. Fig. 55.

Two Ships sail from one place, the one sails SBW, the other WSW, and arrive at two several Ports: The Westermost Port bears from the Eastermost NWBN, then if the distance run of both the Ships and distance between the two Ports be together 130 leagues, I demand them severally.

GEOMETRICALLY.

Draw AB for a SBW, and AC for a SW line, and because we have no side given in the triangle we will suppose the side AB to be 100 leagues: From B draw a NWBW line, so have you finished the triangle ABC, having its angles equal to the angles given in the Question, but its sides are suppositious.

LOGARITHMICALLY.

As sine angle ACB 101°. 15'	999157
Is to side AB 100 leagues	200000
So is sine angle CAB 33. 45	974473
To the side BC 56.65 leagues	175316

As

As sine angle ACB 101°. 15' ——— 99915
Is to side AB 100 leagues ——— 20000
So is sine angle ABC 45°. 06— ——— 98494

To the side AC 72.01 leagues—— ——— 185791

The Sum of these three sides AB. BC. AC is 228.66 leagues, which exceeds 130, therefore say by

Natural Arithmetick.

AB
If 228.66—130—100
100

228.66 | 13000.0000 | 56.85 AB.
114330

156700
37196

195040
182928

121120
114330

6790

If 228.66 -- 130 — 56.65
130

169950
5665

228.66 | 7364.50.00 | 32.20 BC
685988

50470
45732

47380
45732

16480

If 228.66 — 130 — 72.01
130

216030
7201

AG.
228.66 | 9361.300 | 40.94 ferè.
91464

214900
205794

91060

PROOF.

56.85
32.20
40.94

Sum — 129.99

Mr.

Mr. *Richard Norwood* in his Doctrine of Triangles, *Page* 135, has laid down certain Problems which being of uſe to our Seamen, I thought fit to inſert in this place.

A Ship ſailing to windward, will uſually lie within $5\frac{1}{2}$, or 6 points of the Wind, yet by reaſon of her Lee-ward way ſhe will ſcarce make her way good within $6\frac{1}{2}$ points of the Wind, ſometimes more, ſometimes leſs, according as the Sea is rougher or ſmoother, and according to the Mould of the Ship, and ſail ſhe bears: So that in ſailing to a place directly to Windward, ſhe ſails uſually three or four times the diſtance of that place before ſhe arrives at it. But if the place to which ſhe ſails be not directly to Windward, but within a Point, two, three, four, five or ſix points of the Wind, then tho' ſhe turn to Windward, as before, yet ſhe will ſooner arrive at the place than before: But how, and in what proportion, for the one, and for the other may appear by theſe enſuing Problems.

PROB. 10. Fig. 56.

Let the poſition from A to B be South 86 miles, and the Wind at South Then ſuppoſe the Ship intending to ſail from A to B, make her way good within 73°. of the Wind, which is almoſt $6\frac{1}{2}$ points, I demand how far ſhe muſt ſail upon one Tack, and how far upon the other Tack, to arrive at B.

In this Figure AC is the Ships way, ſo near the Wind as ſhe can lie, the angle BAC is 73°. and the angle ABC is equal to it: The Sum of theſe two

angles A and B is 146°. 06 which subtracted from 180°. the remainer is the angle ACB 34°. 06. Therefore say,

As sine angle at C 34°. 06	9·4756
to the side AB 86 Miles	193449
is sine of the angle at A 73°. 00	998059
	1191508
to the side BC 147 Miles	216752

the side FC is equal to the side AC. Therefore the Ship must sail 147 Miles with her Larboard Tack aboard, and as much with her Starboard Tack on board.

PROB. 11. Fig. 57.

Admit the distance from A to E be 96 Miles W. the Wind at South, and let the Ship make way good within 70°. of the Wind: I demand the distances AC, and CE, that is the Ships way dead reckoning upon the one Tack, and upon the other.

Here AB represents a South line, or point, upon which the Wind blows, the angle BAC is 70°. from which subtract the angle BAE 4 points, 45°. the remainer 25°. 06 is the angle EAC. Also the compt. of 70°. is 20°. which doubled is 40°. for the angle at C and by adding these two angles, namely EAC 25°. 06 and ACE 40°. the sum 65°. 06 is the angle AEB by 32. 1 *Euc.* Then in the triangle AEC we have given the side AE 96 Miles, the angles C 40°. and AEC 115°. 06

S (the

Mr. *Richard Norwood* in his Doctrine of Triangles, *Page* 135, has laid down certain Problems which being of use to our Seamen, I thought fit to insert in this place.

A Ship sailing to windward, will usually lie within 5½, or 6 points of the Wind, yet by reason of her Lee-ward way she will scarce make her way good within 6½ points of the Wind, sometimes more, sometimes less, according as the Sea is rougher or smoother, and according to the Mould of the Ship, and sail she bears: So that in sailing to a place directly to Windward, she sails usually three or four times the distance of that place before she arrives at it. But if the place to which she sails be not directly to Windward, but within a Point, two, three, four, five or six points of the Wind, then tho' she turn to Windward, as before, yet she will sooner arrive at the place than before: But how, and in what proportion, for the one, and for the other may appear by these ensuing Problems.

PROB. 10. Fig. 56.

Let the position from A to B be South 86 miles and the Wind at South Then suppose the Ship intending to sail from A to B, make her way good within 73°. of the Wind, which is almost 6½ points, I demand how far she must sail upon one Tack, and how far upon the other Tack, to arrive at B.

In this Figure AC is the Ships way, so near the Wind as she can lie, the angle BAC is 73°. and the angle ABC is equal to it: The Sum of these two

two angles A and B is 146°. 06 which subtracted from 180°. the remainer is the angle ACB 34°. 06. Therefore say,

As sine angle at C 34°. 06 ——	--- 9.4756
to the side AB 86 Miles ——	---- 193449
is sine of the angle at A 73°. 00 ——	998059
	1191508
To the side BC 147 Miles ——	—— 216752

But the side FC is equal to the side AC. Therefore the Ship must sail 147 Miles with her Larboard Tack aboard, and as much with her Starboard Tack on board.

PROB. 11. Fig. 57.

Admit the distance from A to E be 96 Miles W. the Wind at South, and let the Ship make her way good within 70°. of the Wind: I demand the distances AC, and CE, that is the Ships way by dead reckoning upon the one Tack, and upon the other.

Here AB represents a South line, or point, upon which the Wind blows, the angle BAC is 70°. from which subtract the angle BAE 4 points, 45°. the remainer 25°. 06 is the angle EAC. Also the compt. of 70°. is 20°. which doubled is 40°. for the angle at C and by adding these two angles, namely EAC 25°. 06 and ACE 40°. the sum 65°. 06 is the angle AEB by 32. 1 *Euc.* Then in the triangle AEC we have given the side AE 96 Miles, the angles C 40°. and AEC 115°. 06

(the compt. of AEB to 180°. 06.) to find th
AC.CE. Therefore say,

As sine angle ACE 40°. 06 —	— 98
Is to side AE 96 Miles —	— 19
So is sine angle AEC 115°. 06 —	— 995
	1193
To the side AC 135. 3 Miles —	— 213
As sine angle ACE 40°. 06 —	— 980
Is to side the AE 96 Miles —	— 198
So is sine angle EAC 25°. 06 —	— 962
To the side EC 63 Miles —	— 1160
	180

Thus it appears, that to sail from A to which is SW 96 Miles with the Wind at Sou and to make her way good within 70°. 06 of Wind, the Ship must sail with her Larbo Tack aboard 135. 3 Miles, and with her St board Tack on board 63 Miles: Her Course fr A to C being WSW 2°. 30 W. and from C t her Course is EBS 8°. 45′ Southward, or ESE 30 Eastward.

If you desire more Questions of this nature, *Norwood*'s Doctrine of Triangles, *Page* 137. shall not enlarge upon them, because as they capable of sundry improvements which he h omitted, so I shall refer their further Explicati to a more convenient time.

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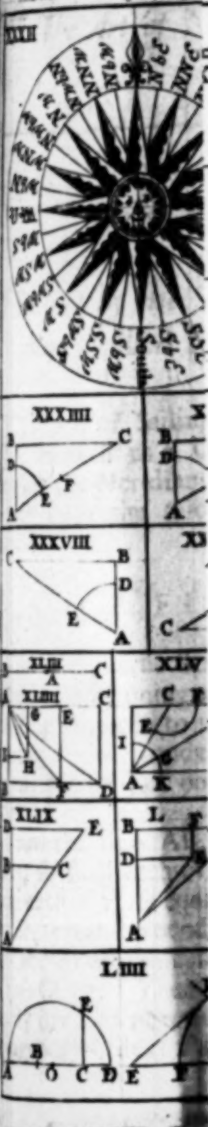
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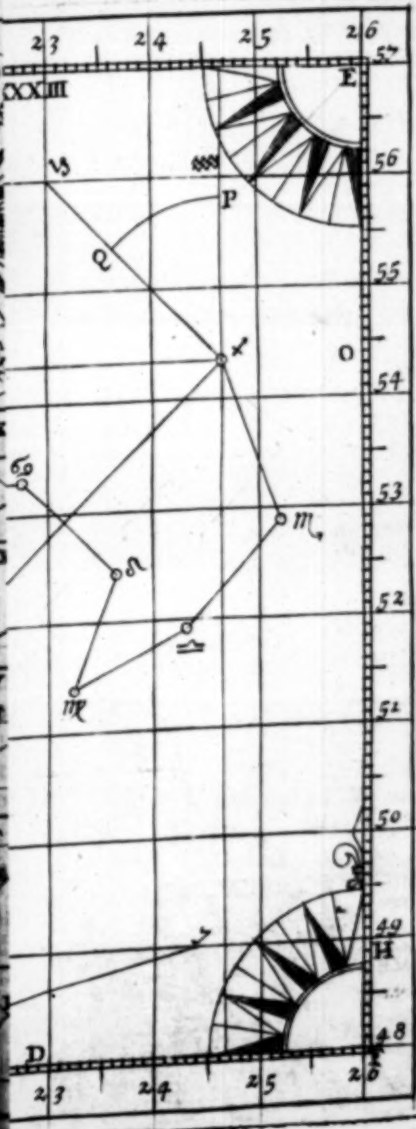
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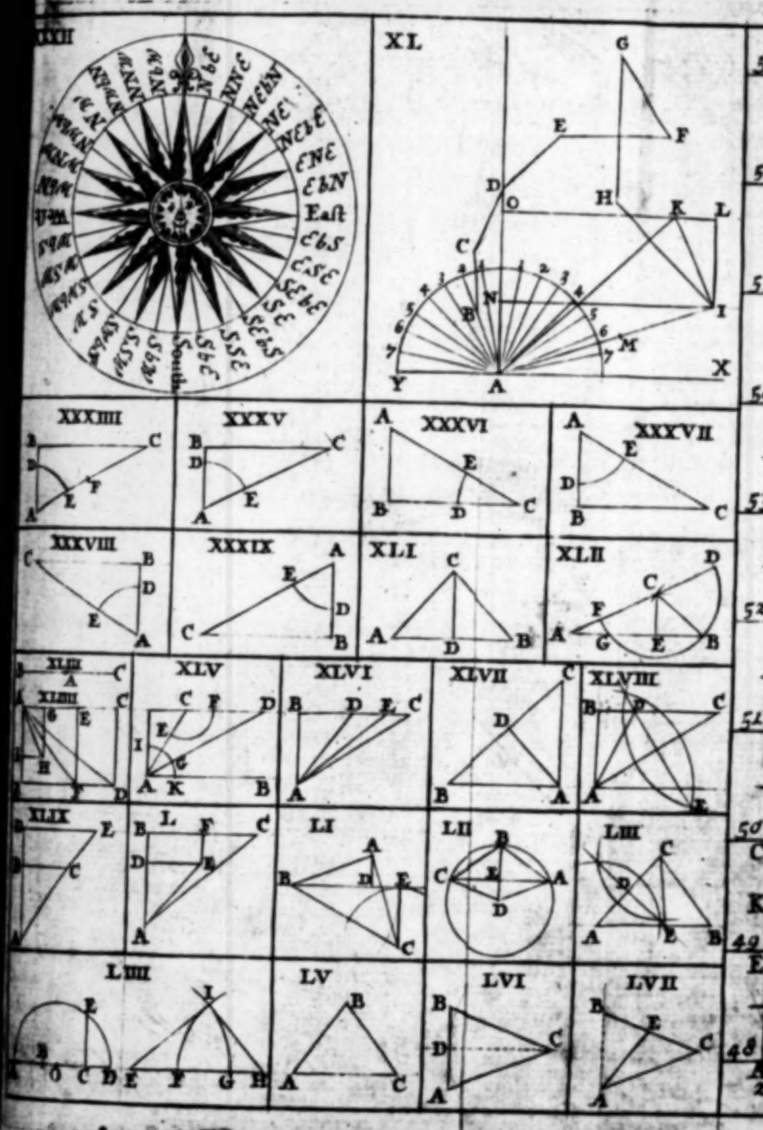
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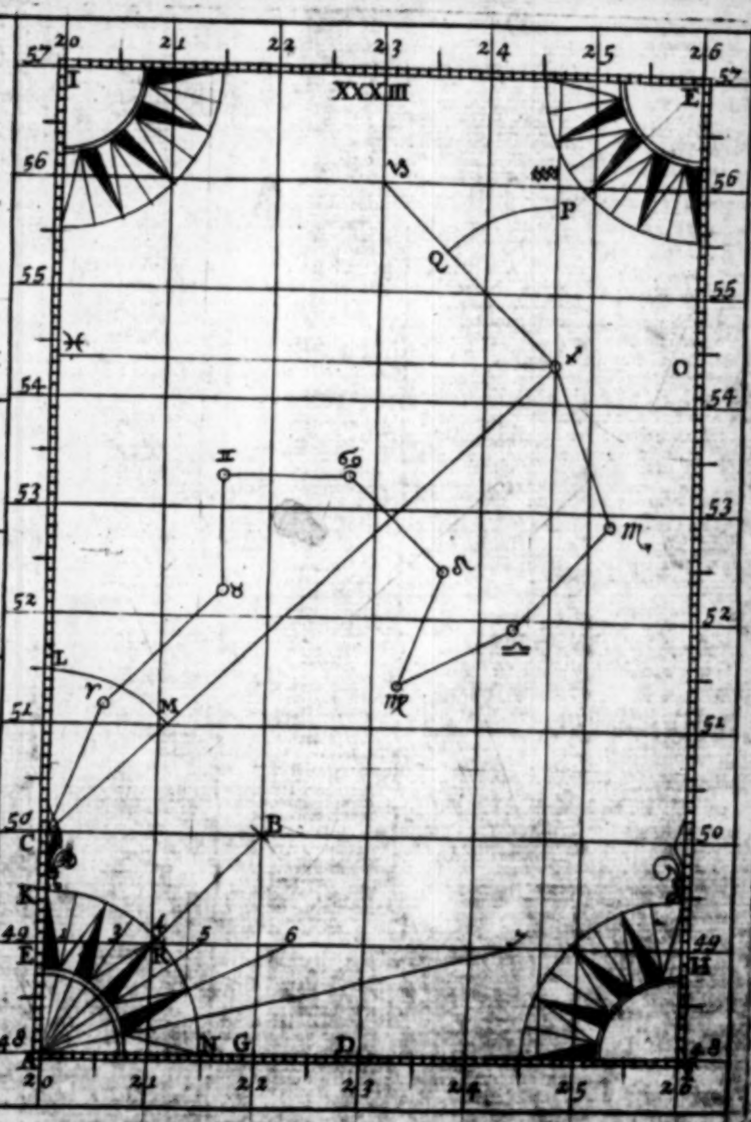
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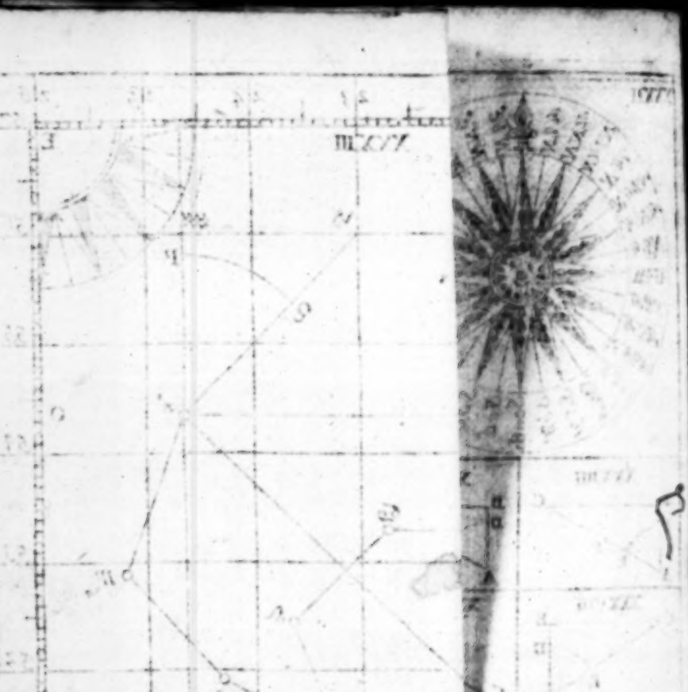

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CHAP. XV.

Of Sailing by the true Sea Chart, commonly called Mercator's *Chart.*

THe way of Sailing by the true Sea Chart, teacheth us a Geographical Method for drawing the Meridians and Parallels of latitude (which upon the Globe are Circles) by right lines.

FIG. 60.

To make a true Sea Chart between any two latitudes, containing any quantity of longitude: Let it be required to make a true Sea Chart, beginning at the latitude of 48°. 06, and ending at the latitude of 54°. 06, containing 8°. of longitude.

Draw the line AB, which divide into 8 equal parts, so shall each of these contain one degree; upon each of these equal parts or degrees of longitude, erect Perpendiculars, as in the Figure, so shall these Perpendiculars represent the Meridians of this Chart. Then Because each degree is commonly divided into 60 equal parts (which I call Sexagenary Miles) therefore divide each degree

into 10 equal parts, so shall each of these small Divisions represent 6 Sexagenary Miles.

Then to graduate the Meridians, find the Meridional parts for the latit. 48°. and 49°. which by the following Table are 3297. and 3381. their diff. is 96 meridional Miles, or 1°. 36'. which take from the line AB, and set from 48°. to 49°. then draw the Parallel of 49°. also find the meridional Miles answering to the latit. 49°. and 50°. the diff. between the two responding numbers will be 93, or 1°. 33', which apply from 49°. to 50°. and draw the Parallel of 50°. and thus you may proceed with all the rest.

Of the use of this Chart.

Draw the line EF, which must be a line of equal parts, or degrees, marked with the same numbers as is the Meridian of the Chart. Each degree in this line must be equal to two degrees in the line AB, and also divided into 10 equal parts. This line so divided, I call the Auxiliary line, whose use I shall explain in these following Cases.

CASE 1. Fig. 60.

Course and distance run given, to find the Ships Latitude and Longitude.

A Ship from the North latit. 48°. 06 and East longitude of 20°. 06. sails N [illegible] 84 miles. I demand her latitude and longitude.

By

By the Chart.

1. From A draw the NEBN line AF, and from the Auxiliary line EF take 1°. 24', or 84 miles, which set from A to F.

2. From F draw FG parallel to AB, and set AG upon the Auxiliary line from A to H, so shall the point H shew the Ship is in the North latit. 49°. 10'.

3. In the Meridian line of the Chart AC find the latitude of 49° 10' which is at K, from K draw KL parallel to AB, so shall AK be the Ships diff. latitude enlarged, *viz.* 105 miles, or 1°.45'. KL the diff. longitude 71 miles, or 1°. 11'. So that by the Chart the Ship is in the North latit. of 49°. 10', and East longitude of 21°. 11. *viz.* at the point L.

There are three several ways in use amongst Seamen for solving Questions of this nature, both Arithmetically and Geometrically, which here not for necessity (for I look upon them all to be unnecessary Follies) but to gratifie all well-wishers to this kind of Learning, I have here inserted them, with some short Notes relating to them.

NOTE 1.

The first way is done by taking the half of the latit. you came from, and the ½ of that latit. you are come into, to both these, add 45°. 06 and seek for the tangents of their two Sums. Subtract the tangent of the lesser arch, from the tangent of the

greater arch, the remainer divided by 126.3, the Quotient ſhall be the meridional miles in the diff. latit. enlarged.

Thus the ½ of 48°. 06 is 24°. 06, to which add 45°. the Sum is 69°. 06, whoſe tangent is 104158226.

Again, the ½ of 49°. 16 is 24°. 35′, to which add 45°. 06, the Sum is 69°. 35′, whoſe tangent is 104291912, the leſſer of theſe tangents ſubtracted from the greater, the remainer is 133686, which divided by 1263, the Quotient is 105 for the miles in the enlarged diff. latitude.

The reaſon whereof is this, If there be a Meridian line, and a line of artificial tangents, both graduated from the ſame line of equal parts, a degree upon this artificial tangent line ſhall be double to a degree upon this Meridian line, and conſequently a minute upon the one, ſhall be double to a minute upon the other. And thus we find the artificial tangent of one minute (omitting the other preceding figures) to be 2527, which by the foregoing reaſon is equal to two minutes upon the Meridian line. Therefore the ½ of this number, *viz.* 1263, will be equal to one minute upon the Meridian line, therefore 133686 (the difference between the two foregoing tangents) divided by 1263, gives the meridional miles required, which exactly anſwer to the Table of Meridional parts.

GEO-

GEOMETRICALLY. Fig. 71.

By the first Case in plain sailing project the triangle ABC, so shall the angle BAC be the Course, AC the distance run, AB the diff. latit. and BC the departure.

By Case 1. of plain sailing, the diff. latit. will be 70 miles, therefore by 1. Rule 1. the Ship is in the North latit. of 49°. 16, which being known, you must (by the preceding Rule) find the diff. latit. enlarged, *viz.* 105 miles, which apply from A to D, and draw DE parallel to BC, so shall AE be the diff. longitude required.

ARITHMETICALLY.

As Radius sine of 90°. 00	1000000
Is to diff. latitude enlarged 105 miles	982489
So is tangent angle BAC 33°. 45′	202118
To diff. longitude DE 70 miles	184607

NOTE 2. Fig. 72.

The second way is by the middle latitude, which depends upon this Theorem.

As the Co-sine of the middle latitude
Is to the Tangent of the Course.
So is the difference of latitude in miles or leagues
To the difference of longitude in miles or leagues.

But this Theorem wants demonstration, and is only to be admitted in short distances, and particularly in latitudes less than 60 degrees. But the

contrivance (whoever was the Author of it) is not altogether contemptible, because it is Geometrically so disposed, that you are to find two like triangles; in the former of which we must always have two parts given, *viz.* the Co-sine of the middle latitude, and tangent of the Course; and in the other we must always have given either the diff. latit. or diff. longit. to find the responding proportional part.

To find the middle latitude, you must always add the latitude you came from, to the latitude you are come to ; ½ that Sum shall be the middle latitude.

GEOMETRICALLY.

1. From C strike the circle DAE, draw the diameters DE.AK at right angles to each other.

2. From A (with the distance AC) strike the arch CB, set the angle of the Course from C to B, and draw the line ABL to cut the diameter DE in O Set the distance run from A to L, and draw LK parallel to DE, so shall AL be the distance run, AK the diff. latitude, and KL the departure.

3. By 1. Rule 1. Chap.12. find the Ships latit. *viz.* 49°. 10, which added to the latitude 48°.00, makes 97°. 10 the ½ whereof, *viz.* 48°. 35' is the middle latitude.

4. From the line of Chords take 48°. 35', and set the same from D to F and G, and draw the line FG to cut DE in H.

5. Set

5. Set CH from C to I, a ruler on I and O will give the line ION. Lastly, make IM equal to AK, and draw MN parallel to DE, so shall MN be the diff. longitude required.

LOGARITHMICALLY.

As Co-sine middle latit. HF.	48°. 35′	982054
Is to tangent of the Course CO	33. 45	982489
So is the diff. latitude IM	70 miles	184500
		1166989
To the diff. longitude MN	71 miles	1′84935

NOTE 3. Fig. 73.

This third way (which really depends upon that of middle latitude) shews us how to find the latitude enlarged Geometrically, thus.

1. By *Case* 1. of Plain Sailing, finish the triangle ABC, in which AB is the true diff. latitude, AC the distance run, and BC the departure.

2. By *Note* 2. find the middle latitude, which set from D to F, and draw FG perpendicular to AB.

3. From A with the distance AG, strike the arch GI; bisect the diff. latit. AB in H, and set AH from G to I, then draw the line AIK.

4. Set DK from A to L, and from L to M, draw MN parallel to BC, so shall AM be the diff. latitude enlarged, and MN the diff. longitude required.

LOGA-

LOGARITHMICALLY.

Find the diff. latit. in Meridional parts between the latit. the Ship came from, and the latit. she is come into, which is 105 miles.

As Radius sine of 90°.00 ——— —— 1000000
Is to diff. latit. enlarged AM 105 miles-—202118
So is t. Course, angl. MAN 33.45 ——— 982489

To diff. longit. MN 71 miles ——— —— 184607

CASE 2.

Both Latitudes, and both Longitudes given, to find the Course and Distance.

A Ship from the North latit. of 48°. 06, and East longitude of 20°. 06, is bound for a Port in the North latit. of 49°. 16, and East longit. of 21°. 11'. I demand her Course and distance.

By the Chart. Fig. 60.

1. It is evident from the Chart, that the first place lies at A, the second at L. Draw a line from A to L; so shall it appear, that the Course from A to L is NEBN.

2. By the Chart it appears, that the line KL lies in the North latit. of 49°. 16. Therefore seek for the latit. of 49°. 16 in the Auxiliary line EF, which you will find at H.

3. From

3. From H draw GF parallel to AB, to cut the line AL continued in F, apply AF upon the auxiliary line from E to I, so shall EI 1°. 24′ be the distance required.

By the Artificial Tangents.

Take the ½ of each latitude, and to it add 45°. then find the tangents of these two Sums. Subtract the tangent of the lesser, from the tangent of the greater, the remainer will be 133686; this divided by 1267, the Quotient 105 is the diff. latit. enlarged.

FIG. 71.

Set the diff. latit. enlarged, *viz.* 105 miles from A to D: Draw DE perpendic. to AD, and by 1. *Rule* 10. *Chap.* 12. find the diff. longit. *viz.* 71 miles, which apply from D to E. Draw the line AE, then in the triangle ADE find the angle DAE, thus.

As diff. latit. enlarged AD 105 ——	202118
Is to Radius sine —— 90°. 00 ——	1000000
So is diff. longit. DE 71 miles ——	184607
To tangent angle DAE 33°. 45′ ——	982489

Also by 1. *Rule* 3. find the true differ. latitude between these two places, *viz.* 1°. 16, or 70 miles, which set from A to B, and draw BC parallel to DE, so shall AC be the distance required.

As

As sine angle ACB 56°. 15′	991984
Is to true diff. latit. AB 70 miles	184500
So is Radius sine of 90.00	1000000
To the distance run 84 miles	192516

By middle Latitude. Fig. 72.

1. Strike the circle, and cross it with two diameters D .AK, at right angles to each other through the center C.

2. Set the diff. latit. given, from A to K, and draw KL perpend. to AK.

3. By *Note* 2. of this Chap. find the middle latitude, which set from D, to F and G; draw FG to cut DE in H; set CH from C to I, and AK from I to M: Draw MN parallel to DE, and set the diff. longit. given from M to N, and draw the line IN to cut DE in O.

4. Lay a Ruler upon A and O, and draw AOL to cut KL in L, so shall AL be the distance required, and KAL the angle of the Course.

LOGARITHMICALLY.

As the true diff. latit. IM 70 miles	184500
Is to true diff. longit. MN 71 miles	184935
So is Co-sine middle latit. CI 48°. 35′	982054
To tangent Course CO 33°. 45′	1166984
	982489

Then

Then in the right angled plain triangle AKL, we have given the diff. latit. AK, and the angle KAL to find the distance AL, say,

As sine angle KLA 56°. 15'————991984
Is to diff. latitude AK 70 miles————184500
So is Radius sine of 90.00————1000000

To the distance required AL 84 miles—192516

By difference of Latitude enlarged Geometrically.

FIG. 73.

1. Draw AM, set the diff. latit. in miles from A to B, draw BC perpen. to AM.

2. Find the middle latit. by *Note* 2. of this Chap. and from A strike the arch DK, upon which set the middle latit. from D to F.

3. Draw FG perpendic. to AB, and strike the arch GI.

4. Bisect AB in H, and set AH from G to I, draw the line AIK, and set DK from A to L, and from L to M, then draw MN parallel to BC, and set the diff. longit. from M to N.

5. Lastly draw AN to cut BC in C, so shall AC be the distance required.

By these two Propositions all the rest may easily be solved, *viz.*

If there be given two Latitudes, and the Course, the distance and diff. longitude may be found.

If one latitude, Course and departure, the other latitude, distance and diff. longitude may be found.

If

If two latitudes and the diſtance be given, the Courſe and diff. longit. may be found.

If the departure and diſtance, with one of the latitudes be given, the other latitude, Courſe and diff. longitude may be found; for all these Caſes depend upon the foregoing Rules, which being very eaſie, and not worth the trouble of inſerting, I leave to the practice of my Reader, and proceed to

CASE 3. Fig. 60.

By one Latitude and diſtance run upon an Eaſt and Weſt Courſe to find the difference of Longitude.

A Ship in the North latit. of 50°. 36 ſails Eaſt 86 miles: I demand her diff. longitude.

By the Chart.

From the Parallel of 50°. 36 draw the line OP, then add ½ the miles in the diſtance run to the latit. given, it makes 51°. 13′, which in the Meridian line falls at M; alſo from the given latit. ſubtract ½ the miles in the diſtance given, and there will remain 49°. 47′, which in the ſame Meridian line will fall at N, apply the diſtance MN from O to P, ſo ſhall OP be the difference of longitude required.

By

By Projection. Fig. 74.

1. Draw the line AB, upon which set the distance given from A to B, from A strike the arch DE.

2. Set the given latit. from D to E, and draw the line AE at length.

3. Upon B, erect the perpend. BC to cut the line AE continued in C, so shall AC be the diff. longitude required.

LOGARITHMICALLY. Fig. 74.

Subtract the latit. given from 90°. 06, the remainer is the angle ACB.

As sine angle ACB 39°. 36 ——	980351
Is to distance run AB 86 miles ——	193449
So is Radius sine of 90°. 00 ——	1000000
To the diff. longit. AC 135 miles ——	213098

CASE 2. Fig. 60.

One Latitude and difference of Longitude given, to find the distance run East or West.

A Ship in the North latitude of 50°. 36. sails East till her diff. longit. be 135 miles. I demand her distance run.

By

By the Chart.

From the latitude given, draw the line OP, and from the line AB take 2°. 35′ equal to 135 miles, and set the same from O to P. Bisect OP in Q, and set OQ from O to M and N upon the Meridian line, so shall the degrees and minutes, contained between the points M and N, *viz.* 1°.26′ (equal to 86 miles) be the distance required.

By Projection. Fig. 74.

Draw AB, from A strike the arch DE, upon which set the latit. 50°. 36 from D to F, draw the line AE at length, and set the diff. longit. from A to C. Bisect AC in F, and from F (with the distance AF) cross AB in B, draw BC, so shall AB be the distance.

LOGARITHMICALLY. Fig. 74.

As Radius sine of 90°. 00 ——— 1000000
Is to diff. longitude AC 135 miles ——— 213098
So is sine angle ACB 39°. 30 ——— 980351

To distance required AB 86 miles ——— 193449

CASE

CASE 5.

Distance run East or West and difference of Longitude given, to find the Latitude sailed in.

A Ship in an unknown Latitude sails 86 miles East, till her difference of Longitude be 135 miles. I demand the Latitude she sailed in.

By the Chart. Fig. 60.

From the line AB take 2°. 15′ (equal to 135 miles) or rather the ½ thereof, *viz.* 1°. 7′½: also the ½ the distance run, *viz.* 43 miles, and apply 1°.7½ (taken from the line AB) so, that it may contain 43 minutes upwards and downwards in the Meridian line, which it will not do till you come to the point O, and there 1°. 7½ will reach from O to M, which is 43 minutes, and from O to N 43′. Therefore O is the point of latit. you have sailed in, which by the Chart appears to be 50°. 36.

By Projection. Fig. 74.

1. Draw the line AB, and set the distance run 86 miles from A to B, then upon B erect the perpendicular BC.
2. Take 135 miles in your Compasses, and with one foot in A, cross the perpend. BC in C.
3. Draw the line AC which shall be the difference of longitude.

Lastly, From A with the Chord of 60°. 0 strike the arch DE, which measured upon the same line of Chords gives 50°. 36 for the latitude in which the Ship has sailed.

LOGARITHMICALLY.

As the diff longit. AC 135 miles	21309
Is to Radius sine of 90°. 00′	100000
So is distance run AB 84 miles	19344
To sine angle ACB 39°. 36	98035

Which subtracted from 90°. 00′, the remainer is 50°. 36 the latitude required.

Some Problems solved by the True Sea Chart.

PROB. 1. Fig. 74.

Two Ships under the Equinoctial are 128 miles asunder, they both sail North to the latit. of 60°. 06. I demand their distance in that Parallel.

This is no more than a different way of expressing that Problem mentioned in *Case* 4. of this Chap. for here we have diff longitude AC 128 miles, and the latitude (angle CAB) 60°. 06. to find the distance AB. therefore say,

As Radius sine of 90°. 00′ ——————— 1000000
Is to diff. longitude 128 miles ——————— 210721
So is sine angle ACB 30°. 00′ ——————— 969897

To distance required AB 64 miles ——— 180618

Thus it appears, that tho' the Ships were 128 miles asunder under the Equinoctial (which is their diff. longitude) yet if they both sail North, or both continue under their first Meridians till they arrive at the Latitude of 60°. 00′. their diff. distance shall be only 64 miles asunder, by reason of the inclinations of the Meridians towards the Poles of the World.

PROB. 2. Fig. 74.

A Ship sails East in an unknown Latitude till he finds that 40 leagues under the Equinoctial, are equal to 64 leagues of that Parallel in which he sails; I demand the latitude of that Parallel.

This Problem is only a different way of expressing that in Case 5. of this *Chap*. Therefore set 40 leagues from A to B; draw BC perpendicular to AB, and from A (with 64 leagues in your Compasses) cross the perpendicular BC in C, and draw the line AC. Lastly, From A (with the Chord of 60°.) strike the arch DE, which being measured upon the same line of Chords, gives 51°. 19′ for the Latitude in which the Ship sailed.

LOGARITHMICALLY.

As diff. longitude AC 64 leagues- ——	180618
Is to Radius sine of 90°. 00′ ———— ——	1000000
So is distance AB 40 leagues ——— . — —	160206
To sine angle ACB 38°. 41′ ———————	979588

Which subtracted from 90. 00 the remainer is 51°. 19′. the Latitude required.

Several other varieties there are of this nature, which I forbear to mention; because I would not swell this Manual farther than I designed it.

To work a Traverse by the True Sea Chart.

A Ship from the North latitude of 51°. 00′, and East longitude of 20°. 00′, sails NNE 45 miles, NE 50 miles, ENE 58 miles, and East 36 miles. I demand her Latitude, Longitude, Course and distance run upon a streight line, by the true Sea Chart.

From R, draw the NNE line R^c, and by *Case* 1. of this *Chap.* find the Ships latitude R 1. and her longitude 1 S. upon that Course and Distance givin, so shall the latitude be 51°. 42′, and her longitude 20°. 29′.

From S draw the NE line ST, and find the Ships true point at T, so shall 2 T lie in the Latitude 52°. 17′, and longitude of 21°. 26′.

From

From T draw the ENE line TV, and find the Ships true point at V, so shall 3 V lie in the latit. of 52°. 39′, and longitude of 22°. 51′.

Lastly, From V draw VW parallel to AB, and by Case 3. of this *Chap.* set the Ships diff. longitude from V to W, then draw the line RW.

Thus from the Chart it appears, that the Ship is come into the North latit. of 52°. 39′, and East longit. of 23°. 50′.

Then to measure the distance RW, you must bisect the Ships difference of latit. 3 R in X, and her distance RW in Y, apply RY from X upwards upon the Meridian line AC, and it will reach to Y a point in the Latitude of 53°. 14′ and applyed downwards upon the same line, it will reach to Z, a point in the latitude of 50°. 24′, the difference between these two Numbers is 2°. 53′, or 173 miles for the Ships distance run.

Or thus.

Find the Latitude 52°. 39′ upon the Auxiliary line, and upon the same line take the distance between the latitude the Ship came from, *viz.* 51°. 00′ and 52°. 39′, apply the same from R (upon the Meridian line) to ♉, draw ♉ ♊ parallel to AB, and continue it to cut RW in ♊, so shall R ♊ (measured upon the Auxiliary line EF) contain 2°. 55′ or 175 miles as afore.

The Course may be measured as in the Cases of plain Sailing.

Having proceeded thus far, I ſhall ſhew yo[u] how to perform the ſame Arithmetically witho[ut] the help of a Chart.

A Journal of my Voyage intended by God'[s] Permiſſion in the *Lyon of London*, Capt. *A. B.* Commander from a Port in the North Latit. o[f] 51°. 00′, and Eaſt longitude of 20°. 00′, to [a] Port in the North latitude of 52°. 39′, and Ea[ſt] longitude of 23°. 50′, ſetting Sail *Decemb.* 8th 1694.

Days of the Month.	Courſes Sailed.	Diſtance in Miles.	Miles Northing.	Miles Southing.	Miles Eaſting.	Miles Weſting.	Differ. Latitude reduced into Deg. and Min.		Latitude North or South	Diff. Longitude reduced into Degr. and Minutes.		Longitude Eaſt or Weſt
							D.	M.		D.	M.	
							51	00	N	20	00	E
De. 8	NNE	45	42		29		0	42		0	29	
							51	42	N	20	29	E
9	NE	50	35		57		0	35		0	57	
							52	17	N	21	26	E
10	ENE	58	22		85		0	22		1	25	
							52	39	N	22	51	E
11	Eaſt	36			59		00	00		0	59	
							52	39	N	23	50	E

EXPLA-

EXPLANATION.

1. By the Calendar find NNE 45 miles, against which stands 42 miles for the Ships difference of latitude, which place under the Miles Northing; then by 1. *Rule* 1. *Chap.* 12. the Ships latitude is 51°. 42′ North.

2. Find the Meridional parts for 51°. 00′, *viz.* 3569, and also for 51°. 42′, *viz.* 3636, the difference is 67 miles for the difference of latitude enlarged, which also place under the miles Northing, below the true difference of latitude. Then say,

As Radius sine of 90°. 00′	1000000
Is to diff. latit. enlarged 67 miles	182607
So is tangent angle Course 22°. 30′	961722
To diff. longitude 29 miles	144329

Then because the Course is NNE place this diff. longitude 29 miles under the miles Easting; then by 1. *Rule* 8. the Ship is in the East longitude of 20°. 29′.

And thus you must proceed with all the other Courses, except the East Course, which is thus to be effected, *viz.* by *Case* 3. of this *Chap.*

As Co-sine Ships latitude 52°. 39′	978296
Is to distance run 36 miles	155630
So is Radius 90°. 00′	1000000
To the diff. longitude 59 Miles	177334

To find the Ships Courſe, you muſt add together all the ſeveral differences of latitude enlarged, *viz.* 67. 57. 36. the Sum whereof is 160. Alſo add together the ſeveral differences of Longitude, *viz.* 29. 57. 85. 59. the Sum whereof is 230. Then ſay,

As Sum of the diff. latit. enlarged	160	220412
Is to Radius ſine angle	90°. 00′	1000000
So is Sum diff. longitude	23°.	236172
To tangent of the Courſe	55°. 11′	1015760

Therefore by *Rule* 12. *Chap.* 12. the Courſe is NEBE 1°. 4′ Northerly. To find the diſtance run upon a ſtreight line, add together all the true differences of latitude, *viz.* 42. 35. 22. the Sum is 99. Then ſay,

As Co-ſine of the Courſe	55°. 11′	975659
Is to Sum true diff. of latitude	99 miles	199563
So is Radius ſine of	90. 00′	1000000
To diſtance run required	173 miles	223904

CHAP.

CHAP. XV.

To keep a Reckoning at Sea by the True Sea Chart.

WE have but few Books extant upon this useful Subject of *Navigation*, where the method of keeping a true Account of the Ships way, either by the Plain, or (as it is commonly call'd) *Mercator*'s Chart is omitted; but whether or no these Books do sufficiently instruct us in this particular, I leave to the Judgment of my Reader.

And for your assistance in this useful piece of skill, take notice of these following Particulars.

1. It is taken for granted amongst our Seamen that the distance between knot and knot in the Log-line, must be 7 Fathom, or 42 Foot. This distance they mark out by measuring seven times the outmost extension of their Arms upon the Log-line: But seeing all Men cannot extend their Arms to one and the same stretch, the distance between the knots of the Log-line, must necessarily be either more or less than seven fathom, or 42 foot, whereas they ought to use all possible diligence in the division of their line, the neglect whereof

whereof does many times occasion great Errours in their Accounts.

2. They ought to examine the quantity of their Glasses, *viz.* whether they be more or less than 30 Seconds, or ½ a Minute, which may be easily done by the Rules in *Chap.* 4. For they usually reckon that if the Ship runs away from the Log, the distance of one knot in the time of one Glass (let the Glass be more or less than ½ a Minute) she must run a mile each hour. But by my Log-Tables, *Chap* 4. it appears that if the Glass be 23 Seconds (the Log-line being always marked at 42 foot) the Ship runs 1.074 mile each hour, that is, one mile and 74 thousand parts of a mile: If the Glass be 24 Seconds, she runs 1.029 miles each hour: If the Glass be 25 Seconds, she runs .0987 miles each hour, that is 987 thousand parts of a mile: And if the Glass be 30 Seconds, she runs but 823 thousand parts of a Mile each hour.

3. The common Instruments used at Sea for finding the Ships true latitude, are cross Staves and Quadrants; in the use whereof they plainly see they take their Solar Meridian Altitudes by the upper Limb of the Sun, and yet never allow for the Suns Semidiameter, which is 16 minutes, which ought always to be subtracted from the Suns Meridian Altitude, otherwise they make it always 16 minutes more than really it is. This Errour added to the Eccentricity of the Eye (as Mr. *Wright* well observes) makes the Suns Meridian Altitude always erroneous.

4. The variation of the Compass is too much neglected, which ought to be enquired into almost continually: For by the Course corrected, and

nd difference of latit. by Obſervation, (which is all the aid we can expect at Sea) the Ships true difference of longitude may in ſome meaſure be gained.

And now ſuppoſing the Young Seaman to be Induſtrious in obſerving theſe four Particulars, I ſhall proceed to direct him in the beſt method I can think of for keeping a Reckoning at Sea.

The firſt thing required in order to keep a true account of the Ships way, is the variation of the Compaſs, which moſt Authors tell you is to be diſcovered by the Suns Oriental or Occidental Amplitude; but the Amplitude cannot be found at Sea, unleſs the Latitude and Suns Declination be given, or elſe the Declination and difference of Aſcenſion be given: And the Latitude cannot be found without the Suns Amplitude, or difference of Aſcenſion: Therefore ſeeing theſe Analagous terms are reciprocal, the one cannot be given without the other, and conſequently (for this purpoſe) neither can be given.

The ſame folly attends the obſervation of the Suns Azimuth, taken by the Azimuth Compaſs: For the Suns true Amplitude, or Azimuth found at Sea is altogether precarious, and conſequently uſeleſs; the beſt way for finding either of them with certainty, is by the Rules in *Page* 158. and when the Compaſs is thus rectified, the Ships true Courſe is known; by help whereof, and the Ships difference of Latit. by obſervation we may by the ſecond Caſe of Plain Sailing find the true Depar-

Departure, which by *Case* 3. of Sailing by the true Sea Chart, may be turned into difference of Longitude.

That the way of keeping an exact Reckoning at Sea, may be better apprehended, I shall give you the form of the Log-Book and Journal both together, which is as followeth.

The

The Form of the Log-Book and Journal, from a Place in the N°. *Latit. of* 50°. 06, *and Longit.* 00°. 06. *setting Sail* June 24. 1694. *Supposing the distance of each Knot upon the Log-line to be* 42 *Feet, and the Glass* 27 *Seconds, the Log-line being cast every Hour.*

Hours	Knots	Fath.	Courses	Winds
1	2	3	NNE	SBW
2	4	5		
3	3	7		
4	1	9		
5	2	0		
6	3	4		
7	2	8		
8	1	7		
9	5	2		
10	3	5		
11	4	2		
12	3	1		
1	2	5		
2	3	6		
3	4	7		
4	3	2		
5	1	4		
6	5	6		
7	1	0		
8	3	1		
9	2	3		
10	3	4		
11	2	7		
12	3	9		
	75	9		

June 24. about 1 a Clock Afternoon we set Sail, with Seven other Ships; a fresh Gale, fair Weather.

By *Chap.* 4.

$$\begin{array}{r} .915 \\ 75.9 \\ \hline 8235 \\ 4575 \\ 6405 \\ \hline \end{array}$$

dist.run by l. 69.4485 m.

Diff.lat.by log—64.1 m.
Depart.by log—26.6 m.
Diff.long.by log-42 mil.

Co-☉ Merid.alt. 28°.13′
☉ Dec. North-- 23.27

Lat. by observat.--51.40

Long.corrected-65.4 m.
Therefore the Ships true Long.is 1°. 5′ *June* 25.
Lat. by Log. 51°. 4′ N°.

June

Hours	Knots	Fath.	Courses	Winds
1	3	5	NE	SW
2	4	6		
3	5	7		
4	4	6		
5	3	5		
6	2	7		
7	4	9		
8	3	8		
9	2	7		
10	1	9		
11	4	5		
12	6	8		
1	5	6	NNE	SW
2	6	5		
3	4	7		
4	6	3		
5	6	4		
6	7	5		
7	6	8		
8	3	4		
9	2	5		
10	7	6		
11	4	7		
12	3	8		

June 26. we had fair Weather, a smooth Sea, the Wind increasing by degrees.

.915	.915
49.2	65.8
1830	7320
8235	4575
3660	5490
dist. 45.0180	*dist.* 60.2070

Diff. latit. by log—93m.
Departure by log-57 m.
Diff.long. by log-93.5 m.
Latitude by log—53°.13′

Co-☉ Merid.alt.-29°.36′
☉ Dec. North-—23.22

Latit. observed—-52.58

Diff.lat.by observ. 1°.33′
Diff.long.corrected 78m.
Ships true longit.--2°.25′
Course corr.N°.31°.36′E.

June

Hours	Knots	Fath.	Courses	Winds
1	4	6	ENE	West
2	5	4		
3	3	7		
4	6	1		
5	5	8		
6	5	7		
7	5	6	NEBN	
8	6	4		
9	6	1		
10	6	2		
11	4	9		
12	4	8		
1	7	4	NEBE	WSW
2	7	5		
3	7	6		
4	8	1		
5	8	2		
6	8	3		
7	7	9	EBN	
8	7	8		
9	7	6		
10	6	8		
11	6	5		
12	6	4		

June 27. we had thick hazy Weather, towards morning it cleared up, and we saw about 4 a Clock 3 Sail on the Starboard bow.

.915	.915
31.3	34
2745	3660
915	2745
2745	31.110
28.6395	

.915	.915
47.1	43
915	2745
6405	3660
3660	39.345
43.0965	

Diff.lat.by log.—69.2 m.
Depart.by log.-117.8 m.
Diff.long.by log.-200 m.
Co. cor. N°.59.46 Eastw.
Latit. by log.54°.07′N°.

Co-☉ merid. alt.-30°.38′
☉ Declin.North—23.22

Lat. by observ.54.00 N°.

Diff.lat.by Observ.62 m.
Diff. long.correct. 61 m.
Ships true longit.--3°.26′

The

The same Log cast every two hours.

Hours	Knots	Fath.	Courses	Winds
2	2	1	ENE	West
4	1	6		
6	1	7		
8	1	8		
10	1	9		
12	1	3		
2	1	6	NE	
4	2	1		
6	2	2		
8	2	2		
10	2	4		
12	2	5		

June 28. Fair Weather, little Wind, we saw 4 Sail more.

.915 .915
20.8 26.0

7320 54900
1830 1830

19.0320 23.7900

Diff.lat.by log.--24.3 m.
Depart. by log.--34.6 m.
Course by log.N°. 55°.E.
Lat. by log.--54°.24'N°.
Diff. long. by log. 58 m.

Co-☉ merid.alt.--31°.36
☉ Dec. North---23.20
Ships lat.by obs. 54.5[illegible] N°

Diff.lat. by observ. 50 m.
Diff.long.correct. 122 m.
Ships true longit. 5°.48'.

EX-

EXPLICATION.

June 24. The Ship sailed upon one Course, viz. NE, and the Log was cast every hour: There-re add up all the Knots and Fathoms (or Deci-l parts of a Knot) and the Snm will be 75.9 or Knots $\frac{9}{10}$.

Thus in the Log-Tables, Chap. 4. find the Ta-e entitled 27 Seconds (which is the supposed antity of time your Glass consists of) and a-inst one Knot stands .915, which multiplyed 75.9 (the number of Knots run in 24 hours) e Product 69.$\frac{4}{10}$ gives the number of Miles the ip shall run that Day.

Thus the Course (always supposed to be cor-ted according to the Rules in Chap. 9. P. 158.) d the Ships distance run by Log, are both own. Therefore by Case 1. of Plain Sailing, u may find the Ships latitude by Log to be 51°. 4′ North, and her longitude by log may be found y Case 1. of Sailing by the true Sea Chart, to be °.42′.

But by a good Observation I find the Ship is in e North latitude of 51°. 46, from which sub-ract the latitude you came from, viz. 50°. 06, the remainer is 1°. 40′ or 100 miles, for the Ships true diff. latitude required.

Then find the meridional parts for the latitude of 51°. 40′, viz. 3632, and also for 50°. 00, viz. 3474, subtract the lesser from the greater, the remainer 158 is the difference of the latitude en-larged, then say,

U As

As Radius sine of 90°. 00′ ———— 100000
Is to diff. latit. enlarged 158 Miles ———— 21986
So is tangent Course 22°. 36 ———— 96172

To Ships true diff. long. 65.4 Miles —— 18158

Therefore the Ships true longitude is 1°. 5′.

Again, To find the Ships difference of long. by Log. Seeing that the Course is NNE, and distance 69.4 Miles therefore by the Tables of Latitude and Departure, it is evident, That the Ships difference of latit. by Log. is 64.1 Miles, and her Departure is 26.6 Miles, and consequently by 1. *Rule* 1. *Chap.* 12. the Ships latitude by Log is 51°. 4′. North, find the Meridional parts for the Latitude you came from, *viz.* 50°. 06, and that Latitude you are come into by Log. which by the Tables in *Page* 138, are as follow, *viz.* 3474 and 3575, subtract the lesser from the greater, and the remainer 101. is the difference of Latitude enlarged. Then say,

As Radius sine of 90°. 06 ———— 1000000
Is to difference of Latitude enlarged 101 - 200432
So is tangent Course 22°. 36 ———— 961722

To Ships diff. Long. by Log. 41.8 Miles — 162154

Or you may find the Ships difference of Long. by Log. according as I directed you in *Case* 3. of Sailing by the true Sea Chart; for the departure in this case is nothing but the Ships distance run East or West in that.

June

June 26.

In this days motion, the Ship sails upon two
eral Courses, *viz.* NE and NNE, to find her
tance run upon each Course, add up all the
ots and Tenths the Ship run NE, which was
12 hours time, and the Sum is 49.2, that is
Knots, and $\frac{2}{10}$ of a Knot, consequently her
ance run will be 45 Miles upon that Course.
so her distance run upon the NNE Course will
65.8 Miles, with which you may proceed ac-
ding to the Directions in *Page* 198 and 199,
having found the Ships difference of Lat. and
parture, her Course may easily be discovered
Case 6. of Plain Sailing, and then the Ships
itude and Longitude by Log. may be found as
re, as also her corrected difference of Longit.

The last thing I have to observe to you is, that
ne 28. the Log was cast but once every 2 hours.
he first Course was ENE, the Sum of the Knots
d Fathoms (or Decimals of a Knot) is 10.4,
hich doubled, makes 20.$\frac{8}{10}$ Knots. The other
urse is NE. and the Sum of the Knots is 13,
hich being doubled, makes 26, these two Num-
rs multiplied by the responding number in the
g-Tables, give the Ships distance as afore.

Thus you see how easie a thing it is to keep a
od account of the Ships reckoning by Log, and
so how to correct this Account by a good Ob-
servation. The want of these or the like plain
d demonstrative Rules, has been the occasion
of many Erroneous Accounts.

As Radius fine of 90°. 00′ ——— 10000[illegible]
Is to diff. latit. enlarged 158 Miles —— 21986
So is tangent Course 22°. 30 ——— 96172

To Ships true diff. long. 65.4 Miles —— 18158

Therefore the Ships true longitude is 1°. 5′.

Again, To find the Ships difference of long. by Log. Seeing that the Course is NNE, and distance 69.4 Miles therefore by the Tables of Latitude and Departure, it is evident, That the Ships difference of latit. by Log. is 64.1 Miles, and her Departure is 26.6 Miles, and consequently by 1. *Rule* 1. *Chap*. 12. the Ships latitude by Log is 51°. 4′. North, find the Meridional parts for the Latitude you came from, *viz*. 50°. 00, and that Latitude you are come into by Log, which by the Tables in *Page* 138, are as follow, *viz*. 3474 and 3575, subtract the lesser from the greater, and the remainer 101. is the difference of Latitude enlarged. Then say,

As Radius fine of 90°. 00 ——— 1000000
Is to difference of Latitude enlarged 101 - 200432
So is tangent Course 22°. 30 ——— 961722

To Ships diff. Long. by Log. 41.8 Miles — 162154

Or you may find the Ships difference of Long. by Log, according as I directed you in *Case* 3. of Sailing by the true Sea Chart; for the departure in this case is nothing but the Ships distance run East or West in that.

Jnne

June 26.

In this days motion, the Ship sails upon two several Courses, *viz.* NE and NNE, to find her distance run upon each Course, add up all the Knots and Tenths the Ship run NE, which was in 12 hours time, and the Sum is 49.2, that is 49 Knots, and $\frac{2}{10}$ of a Knot, consequently her distance run will be 45 Miles upon that Course. So her distance run upon the NNE Course will be 65.8 Miles, with which you may proceed according to the Directions in *Page* 198 and 199, and having found the Ships difference of Lat. and Departure, her Course may easily be discovered by *Case* 6. of Plain Sailing, and then the Ships Latitude and Longitude by Log. may be found as before, as also her corrected difference of Longit.

The last thing I have to observe to you is, that June 28. the Log was cast but once every 2 hours. The first Course was ENE, the Sum of the Knots and Fathoms (or Decimals of a Knot) is 10.4, which doubled, makes 20.$\frac{1}{10}$ Knots. The other Course is NE. and the Sum of the Knots is 13, which being doubled, makes 26, these two Numbers multiplied by the responding number in the Log-Tables, give the Ships distance as afore. Thus you see how easie a thing it is to keep a good account of the Ships reckoning by Log, and also how to correct this Account by a good Observation. The want of these or the like plain and demonstrative Rules, has been the occasion of many Erroneous Accounts.

As Radius sine of 90°. 00′ ——————— 10000[illegible]
Is to diff. latit. enlarged 158 Miles—————2198[illegible]
So is tangent Course 22°. 30 —————— 96172[illegible]

To Ships true diff. long. 65.4 Miles—— 18158[illegible]

Therefore the Ships true longitude is 1°. 5′.

Again, To find the Ships difference of long. b[illegible] Log. Seeing that the Course is NNE, and d[illegible] stance 69.4 Miles therefore by the Tables o[illegible] Latitude and Departure, it is evident, That th[illegible] Ships difference of latit. by Log. is 64.1 Miles, an[illegible] her [illegible] by [illegible] is [illegible] the [illegible] tha[illegible] by [illegible] 34[illegible] gre[illegible] Latitude enlarged. Then say,

As Radius sine of 90°. 06 ——— 1000000
Is to difference of Latitude enlarged 101-200432
So is tangent Course 22°. 30 ——— ——— 961722

To Ships diff. Long. by Log. 41.8 Miles —162154

Or you may find the Ships difference of Long. by Log according as I directed you in *Case* 3. of Sailing by the true Sea Chart; for the departure in this case is nothing but the Ships distance run East or West in that.

June

June 26.

h this days motion, the Ship sails upon two ral Courses, *viz.* NE and NNE, to find her ance run upon each Course, add up all the ts and Tenths the Ship run NE, which was 12 hours time, and the Sum is 49.2, that is Knots, and ,^{2} of a Knot, consequently her ance run will be 45 Miles upon that Course, o her distance run upon the NNE Course will 14.8 Miles, with which you may proceed ac- o the Directions in *Page* 198 and 199, ound the Ships difference of Lat. and er Course may easily be discovered Plain Sailing, and then the Ships Longitude by Log. may be found as her corrected difference of Longit.

hing I have to observe to you is, that Log was cast but once every 2 hours. urse was ENE, the Sum of the Knots thoms (or Decimals of a Knot) is 10.4, ich doubled, makes 20.1^{8} Knots. The other rse is NE. and the Sum of the Knots is 13, ich being doubled, makes 26, these two Num- s multiplied by the responding number in the g-Tables, give the Ships distance as afore. us you see how easie a thing it is to keep a d account of the Ships reckoning by Log, and o how to correct this Account by a good Ob- vation. The want of these or the like plain d demonstrative Rules, has been the occasion f many Erroneous Accounts.

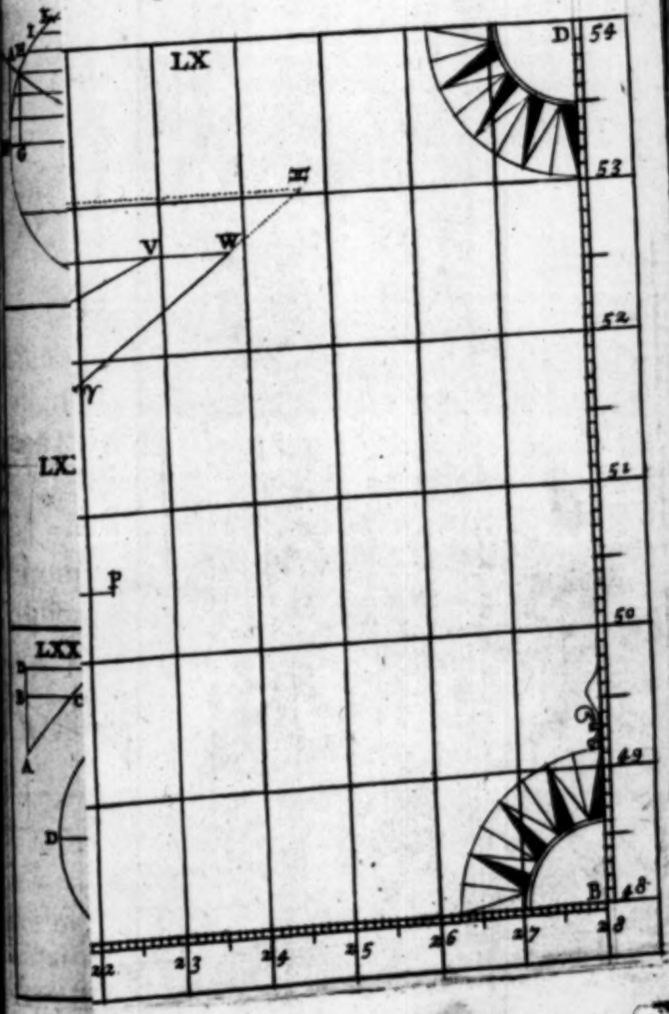
To conclude, it were much to be
our Seamen would be at the pains fi
and then to practise those Rules I ha
in Chap. 2. and Chap. 7. the one teac
find the Latitude of any place whe
come (and that by a Quadrant of 18 o
Radius, furnished with an Index and S
side of the Quadrant lying in an Horiz
tion) the other shewing how (as in *Pa*
find the true Longitude of the same p
the Shoar by help of a good Telescope
Foot long.

By this means would the business of G
be compleat, and thereby the Art of N
would attain its desired perfection.

And for want of this due care, not
Longitudes of Places (which in themse
difficult to be found) are many times two
degrees, and sometimes more, different
truth; but also the Latitudes of several Pl
false set, both in our Geographical Maps
bles, as you may see in the Voyage to
1685.

Now seeing the Latitudes and Longitu
Places are too many times falsly set down,
it possible to keep a true account in Sailin
tween any two of these Places?

FINIS.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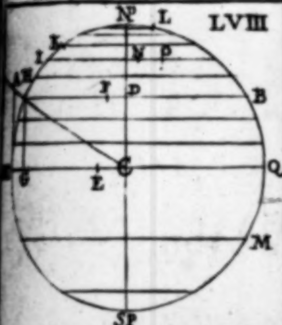
LVIII



LIX

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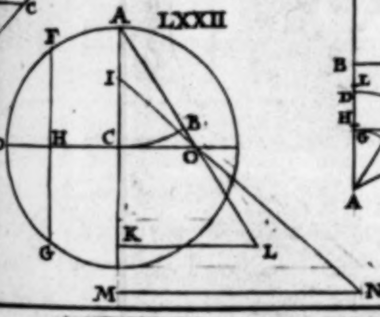
LXXI

LXXII



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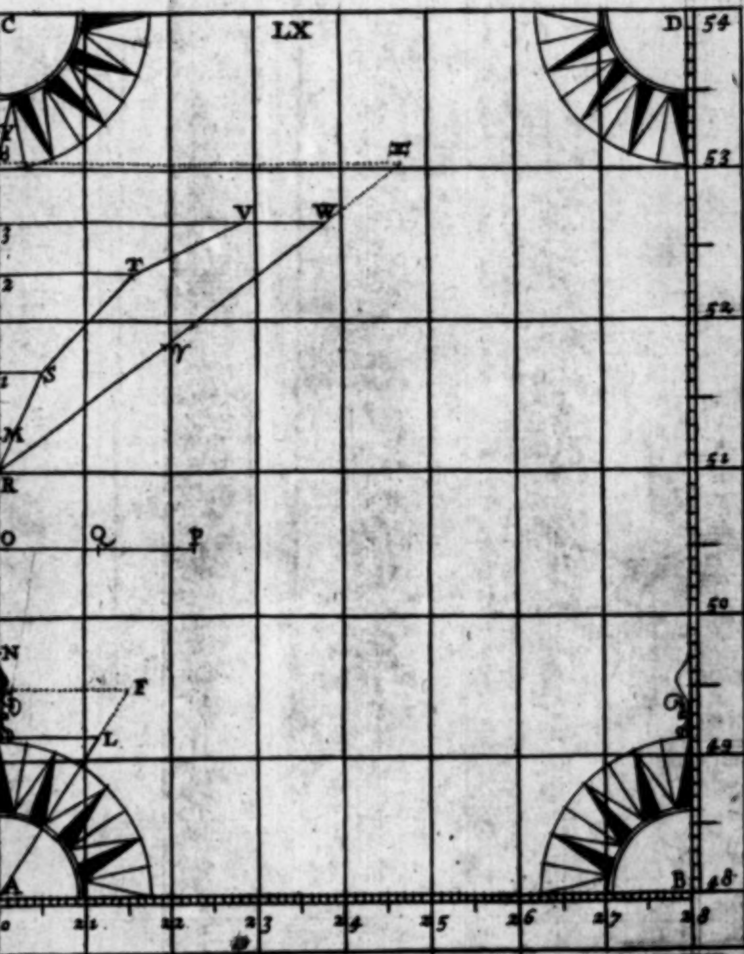
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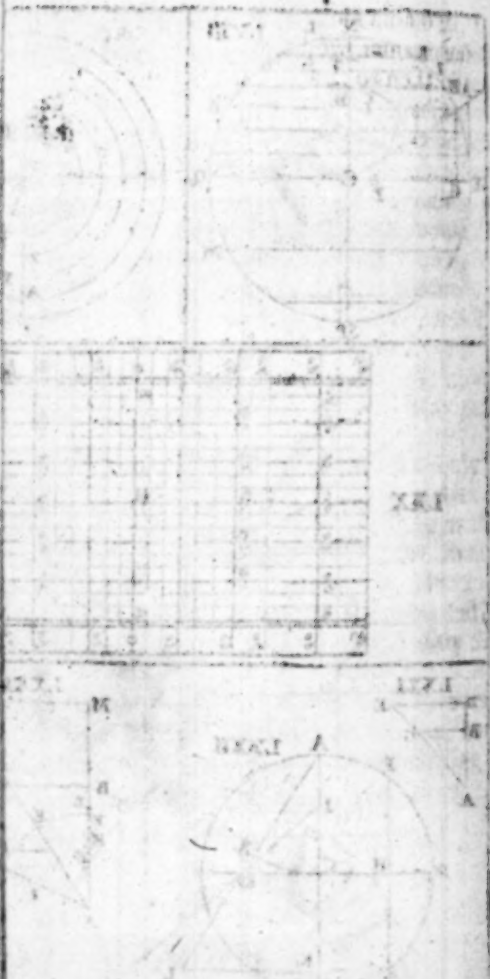

ASTRONOMICAL

TABLES

OF THE

SUN and *STARS.*

SHEWING

he Sun's Right Ascension and Decli-
nation for every Degree of the
Sun's Place in the *Ecliptic.*

AND

he Longitude, Latitude, Right A-
scension and Declination of most of
the Fixed Stars in both *Hemispheres.*

Rectified for the Year 1700.

LONDON,
inted by *J. Orme*, for *Christopher Hussey*, at
the three *Flower-de-Luce's* in *Little Bri-
tain*, 1695.

ASTRONOMICAL

TABLES

OF THE

... and STARS.

SHEWING

the Stars Right Ascension and Decli-
nation to every Degree of the
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Longitude, Latitude, Right A-
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Rectified for the Year ...

LONDON,
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tain, 1695.

D.	☉ R.As. H. M.	☉ Dec. D. M.	N or S	☉ place ♉ D.	☉ R.As. H. M.	☉ Dec. D. M.	N or S	☉ place ♊ D.	☉ R.As. H. M.	☉ Dec. D. M.	N or S
1	0. 4	0.24	N	D.1	1.55	11.51	N	D.1	3.55	20.25	N
2	0. 7	0.48	N	2	1.59	12.13	N	2	4.00	20.37	N
3	0.11	1.12	N	3	2.03	12.33	N	3	4.04	20.49	N
4	0.15	1.36	N	4	2.07	12.53	N	7	4.08	21.00	N
5	0.18	2.00	N	5	2.11	13.15	N	5	4.12	21.11	N
6	0.22	2.2[illegible]	N	6	2.14	13.33	N	6	4.16	21.22	N
7	0.26	2.48	N	7	2.18	13.55	N	7	4.21	21.32	N
8	0.29	3.11	N	8	2.22	14.13	N	8	4.25	21.43	N
9	0.33	3.35	N	9	2.26	14.32	N	9	4.29	21.52	N
10	[illegible]	3.58	N	10	2.30	14.50	N	10	4.33	22.00	N
11	[illegible]	[illegible]	N	11	2.3	15.10	N	11	4.38	22.12	N
12	[illegible]	4.46	N	12	2.38	15.29	N	12	4.42	22.17	N
13	[illegible]	5.09	N	13	2.42	15.47	N	13	4.46	22.25	N
14	0.52	5.3[illegible]	N	14	2.46	16.05	N	14	4.51	22.33	N
15	0.55	5.56	N	15	2.50	16.23	N	15	4.55	22.40	N
16	0.59	6.18	N	16	2.54	16.40	N	16	4.59	22.46	N
17	1.03	6.42	N	17	2.58	16.56	N	17	5.04	22.52	N
18	1.06	7.05	N	18	3.02	17.1	N	18	5.08	22.58	N
19	1.10	7.28	N	19	3.06	17.31	N	19	5.12	23.02	N
20	1.14	7.50	N	20	3.10	17.48	N	20	5.17	23.07	N
21	1.18	8.12	N	21	3.14	18.03	N	21	5.21	23.12	N
22	1.21	8.36	N	22	3.18	18.19	N	22	5.25	23.15	N
23	1.25	8.58	N	23	3.22	18.35	N	23	5.30	23.19	N
24	1.29	9.21	N	24	3.26	18.49	N	24	5.34	23.21	N
25	1.33	9.43	N	25	3.31	19.05	N	25	5.38	23.24	N
26	1.36	10.04	N	26	3.[illegible]	19.18	N	26	5.43	23.26	N
27	1.40	10.26	N	27	3.39	19.32	N	27	5.47	23.28	N
28	1.44	10.48	N	28	3.43	19.45	N	28	5.51	23.29	N
29	1.48	11.09	N	29	3.47	19.59	N	29	5.56	23.30	N
30	1.52	11.30	N	30	3.51	20.12	N	30	6.00	23.30	N

☉ place ♋	☉ R.Asc. H. M.	☉ Dec. D. M	N or S	☉ place ♍	☉ R. Asc. H. M	☉ Dec. D. M	N or S	☉ place ♌	☉ R. Asc H. M.	☉ Dec. D. M.
D.1	6.04	23.30	N	D.1	8.13	19.57	N	D.1	10.12	11.06
2	6.09	23.25	N	2	8.17	19.43	N	2	10.16	10.45
3	6.13	23.27	N	3	8.21	19.29	N	3	10.29	10.23
4	6.18	23.25	N	4	8.25	19.15	N	7	10.24	10.01
5	6.22	23.23	N	5	8.29	29.62	N	5	10.27	9.43
6	6.26	23.21	N	6	8.34	18.46	N	6	10.31	9.17
7	6.31	23.18	N	7	8.38	18.32	N	7	10.35	8.55
8	6.35	23.15	N	8	8.42	18.16	N	8	10.39	8.32
9	6.39	23.12	N	9	8.46	18.00	N	9	10.42	8.09
10	6.44	23.08	N	10	8.50	17.4[illegible]	N	10	19.46	[illegible].47
11	6.48	23.04	N	11	8.54	17.18	N	11	10.50	[illegible].24
12	6.52	23.01	N	12	[illegible].58	17.11	N	12	10.53	7.01
13	6.57	12.58	N	13	9.02	16.54	N	13	10.57	6.38
14	7.01	22.50	N	14	9.06	16.38	N	14	11.01	6.15
15	7.05	22.44	N	15	9.10	19.20	N	15	11.[illegible]5	5.52
16	7.09	22.36	N	16	9.14	16.02	N	16	11.08	5.29
17	7.14	22.28	N	17	9.18	15.44	N	17	11.12	5.25
18	7.28	22.20	N	18	9.22	15.26	N	18	11.16	4.42
19	7.22	22.11	N	19	9.25	15.07	N	19	11.20	4.18
20	7.27	22.00	N	20	9.30	14.47	N	20	11.23	3.54
21	7.31	21.52	N	21	9.34	14.28	N	21	11.27	3.31
22	7.36	21.43	N	22	9.38	14.10	N	22	11.31	3.07
23	7.40	21 32	N	23	9.41	13.52	N	23	11.34	2.4
24	7.44	21.21	N	24	9.45	13.30	N	24	11.38	2.2[illegible]
25	7.48	21.10	N	25	9.49	13.11	N	25	11.42	1.5[illegible]
26	7.52	20.58	N	26	6.53	[illegible].51	N	26	11.46	1.[illegible]
27	7.56	20.47	N	27	9.57	12.30	N	27	11.49	[illegible]
28	8.00	2[illegible].35	N	28	0.01	12.09	N	28	11.53	0.4[illegible]
29	8.05	20.23	N	29	10.65	11.48	N	29	11.57	0.20
30	8.[illegible]	[illegible]0	N	30	10.08	11.27	N	30	12.00	0.00

☉ R. Asc.	☉ Dec.	N or S	☉ place	☉ R. Asc.	☉ Dec.	N or S	☉ place	☉ R. Asc.	☉ Dec.	N or S
H. M.	D. M	S	♏	H. M	D. M	S	♐	H. M	D. M.	S
12.04	0.24	S	D.1	13.55	11.51	S	D.1	15.55	20.25	S
12.07	0.48	S	2	13.59	12.13	S	2	15.59	20.37	S
12.11	1.12	S	3	14.03	12.33	S	3	16.04	20.49	S
12.15	1.36	S	4	14.07	12.5[illegible]	S	4	16.08	21.00	S
12.18	2.00	S	5	14.11	13.15	S	5	16.12	21.[illegible]	S
12.22	2.24	S	6	14.15	13.33	S	6	16.16	21.22	S
12.26	2.4[illegible]	S	7	14.19	13.55	S	7	16.21	21.32	S
12.29	3.11	S	8	14.23	14.13	S	8	16.25	21.43	S
12.33	3.35	S	9	14.26	14.32	S	9	16.29	21.51	S
12.37	3.58	S	10	14.3[illegible]	14.50	S	10	16.33	22.00	S
12.40	4.22	S	11	14.[illegible]4	15.10	S	11	16.37	22.10	S
12.44	4.46	S	12	14.38	15.29	S	12	16.42	22.17	S
12.48	5.09	S	13	14.42	15.47	S	13	16.46	22.25	S
12.52	5.33	S	14	14.46	16.05	S	14	16.50	22.33	S
12.55	5.56	S	15	14.4[illegible]	16.23	S	15	16.55	22.39	S
12.59	6.18	S	16	14.5[illegible]	16.40	S	16	16.59	22.46	S
13.03	6.42	S	17	14.5[illegible]	16.56	S	17	17.03	22.52	S
13.06	7.05	S	18	15.02	17.14	S	18	17.08	22.58	S
13.10	7.28	S	19	15.0[illegible]	17.31	S	19	17.12	23.02	S
13.14	7.50	S	20	15.1[illegible]	17.48	S	20	17.16	23.07	S
13.18	8.12	S	21	15.1[illegible]	18.03	S	21	17.21	23.12	S
13.21	8.36	S	22	15.1[illegible]	18.19	S	22	17.25	23.15	S
13.25	8.58	S	23	15.2[illegible]	18.35	S	23	17.29	23.19	S
13.29	9.21	S	24	15.2[illegible]	18.49	S	24	17.34	23.21	S
13.33	9.43	S	25	15.3[illegible]	19.05	S	25	17.38	23.24	S
13.36	10.04	S	26	15.3[illegible]	19.18	S	26	17.43	23.26	S
13.40	10.25	S	27	15.35	19.32	S	27	17.47	23.28	S
13.44	10.48	S	28	15.4[illegible]	19.45	S	28	17.51	23.29	S
13.47	11.09	S	29	15.47	19.59	S	29	17.56	23.29	S
13.51	11.30	S	30	15.51	20.12	S	30	18.00	23.[illegible]0	S

☉ place	☉ R. Asc	☉ Dec.	No or So	☉ place	☉ R. Asc.	☉ Dec.	No or So	☉ place	☉ R. Asc.	☉ Dec
♑	H. M.	D. M	So	♒	H. M	D. M.	So	♓	H. M.	D.
D.1	18.04	23.30	S	D.1	20.13	19.57	S	D.1	22.12	11.0
2	18.09	23.29	S	2	20.17	19.43	S	2	22.16	10.4
3	18.13	23.27	S	3	20.21	19.29	S	3	22.20	10.2
4	18.17	23.26	S	4	20.25	19.15	S	4	22.24	10.0
5	18.22	23.24	S	5	20.29	19.02	S	5	22.27	9.3
6	18.26	23.21	S	6	20.34	18.46	S	6	22.31	9.1
7	18.31	23.18	S	7	20.38	18.32	S	7	22.35	8.5
8	18.35	23.15	S	8	20.42	18.16	S	8	22.39	8.3
9	18.39	23.11	S	9	20.46	18.00	S	9	22.42	8.0
10	18.44	23.06	S	10	20.50	17.45	S	10	22.46	7.4
11	18.48	23.01	S	11	20.54	17.28	S	11	22.50	7.2
12	18.52	22.57	S	12	20.58	17.11	S	12	22.54	7.[illegible]
13	18.56	22.51	S	13	21.02	16.54	S	13	22.57	6.3
14	19.00	22.45	S	14	21.06	16.38	S	14	23.00	6.1
15	19.05	22.38	S	15	21.10	16.20	S	15	23.04	5.5
16	19.09	22.31	S	16	21.14	16.02	S	16	23.08	5.29
17	19.14	22.24	S	17	21.18	15.44	S	17	23.12	5.0
18	19.18	22.16	S	18	21.22	15.26	S	18	23.16	4.4
19	19.22	22.08	S	19	21.26	15.07	S	19	23.20	4.18
20	19.27	21.59	S	20	21.30	14.47	S	20	23.23	3.54
21	19.31	21.50	S	21	21.34	14.28	S	21	23.27	3.31
22	19.35	21.41	S	22	21.37	14.10	S	22	23.31	3.07
23	19.39	21.30	S	23	21.41	13.52	S	23	23.34	2.44
24	19.44	21.20	S	24	21.45	13.30	S	24	23.38	2.20
25	19.48	21.09	S	25	21.49	13.11	S	25	23.42	1.56
26	19.52	20.58	S	26	21.53	12.51	S	26	23.46	1.32
27	19.56	20.47	S	27	21.57	12.30	S	27	23.49	1.08
28	20.00	20.35	S	28	22.01	12.09	S	28	23.53	0.44
29	20.05	20.23	S	29	22.04	11.48	S	29	23.57	0.20
30	20.09	20.10	S	30	22.08	11.27	S	30	24.00	0.00

A TABLE *containing the Names of the Fixed Stars Rectified for the Year* 1700.

URSA Minor: Or,

LAST Star in the Tayl, called the *Pole-Star* —
Uppermost Guard — — — —
Lowermost Guard - — — — — —

URSA Major: Or,

Brightest in the Right Knee— - - — —
Upper pointer, *Dubbe* — — — —
Lower pointer- — — — — —
Upper following in the Square — —
Lower in the same — — — —
In the Root of the Tayl, *Aliot* — — — — -
Second in the Tayl — — — — —
In the end of the Tayl, *Benenacz* — - —
Cor Caroli — — — — — — -

DRACO.

Former of the two Bright ones in the Head —
Bright one in the Head, *Arato Ras Aben* — —
Last but one in the Tayl — — — —
Last in the Tayl- — — — — —

CEPHEUS.

Longitude D. M. S.		Latit. D. M.	N or S	Decl. D. M.	N or S	R. Asc. H. M.	Magni.

The Little BEAR.

22.25.50	♊	66.02	N	87.42	N	00.44	2
8.39.50	♌	72.51	N	75.30	N	21.10	2
16.04.20	♌	75.23	N	73.10	N		3

The Great BEAR.

1.55.50	♌	34.34	N	53.02	N	9.05	3
10.57.20	♌	49.40	N	63.32	N	10.45	2
15.06.50	♌	45.03	N	57.58	N	10.43	2
26.48.50	♌	51.37	N	58.41	N	11.56	2
26.08.20	♌	47.06	N	55.23	N	11.37	2
4.33.20	♍	54.18	N	57.39	N	12.40	2
11.19.50	♍	56.22	N	56.41	N	13.12	2
22.35.20	♍	54.25	N	50.53	N	13.35	2
19.06.20	♍	40.06	N	40.25	N	12.40	2

The DRAGON.

7.42.20	♐	75.21½	N	52.32	N	17.24	3
23.47.20	♐	75.03½	N	51.35	N	17.52	3
11.49.50	♌	61.33	N	71.25	N	12.18	3
6.00.50	♋	57.07	N	71.00	N	11.15	3

CEPHEUS.

CEPHEUS.

In his Girdle- ——————————————
In his Shoulder, *Alderab* ——————————
In his Left Foot ————————————

BOOTES.

In his Shoulder, *Ceginus* ——————————
In his Head——————————————
In his Right Shoulder, above the Crown ——
Below the Right Arm in the Hip, *Mezen* ——
In his Skirt, *Arcturus*, *Azimeck*, *Alrameck* ——

CORONA BOREA.

Brightest, *Alfeta* ——————————
Next the Bright Star ——————————

HERCULES.

In his Head, *Ras Algiethber*, *Arace-* ————
In his Right Shoulder ——————————
Left but one in his Right Arm, *Marsic*————
In his Left Shoulder - ——————————
In his Left Knee — ——————————

LYRA.

Brightest, *Asengue*, *Allore*, *Brinesce*————
Northern of the two in the Yoke- ——————
Next Bright one Eastward———————

CIGNUS.

Longitude D. M. S.		Latitud. D. M.		Declin. D. M.		R. Ascen. H. M	Magn.

CEPHEUS.

1.36.20	♉	71.07	N	69.17	N	21.25	3
8.36.20	♉	68.54	N	61.17	N	21.11	3
25.46.20	♉	64.28	N	75.50	N	23.33	3

BOOTES.

14.28.50	♎	49.33½	N	39.17	N	14.23	3
2 .06.50	♎	54.15½	N	41.38	N	15.15	3
28.52.50	♎	49.01	N	34.28	N	15.04	3
23.52.20	♎	40.40	N	28.22	N	14.32	3
20.02.20	♎	31.02½	N	20.50	N	14.02	1

The Northern Crown.

8.01.50	♏	44.23	N	27.46	N	15.22	2
10.37.50	♏	44.52	N	27.04	N	15.41	4

HERCULES.

11.54.20	♐	37.23	N	14.49	N	17.01	3
26.50.50	♏	42.48	N	22.40	N	16.17	3
24.59.20	♏	40.05½	N	19.55	N	16.09	3
10.33.20	♐	47.47	N	25.13	N	17.03	3
24.19.20	♐	60.47½	N	46.14	N	17.31	3

The HARP.

11.06.20	♑	61.47	N	38.32	N	18.27	1
14.26.50	♑	56.05	N	33.04	N	18.38	3
17.34.20	♑	55.06	N	32.19	N	18.47	3

The

CYGNUS.

In the Bill, *Albireo*
In her Breast
In her Tayl, *Arides*
First & brightest in the Bend of the higher Wing
Middlemost in the lower Wing

CASSIOPEIA.

In her Breast, *Schedir*
In her Bending towards the Hip
In her Knee
In her Leg
Bright one in the Chair

PERSEUS.

In his Right Shoulder
Bright one in his side, *Algenib*
Next in the Bend of his side
Medusa's Head, *Algol*

AURIGA.

In his Right Shoulder
In his Left Shoulder, *Capella*
In his Right Foot

OPHI-

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R.Ascen. H. M.	Magn.

The SWAN.

27.07.20	♑	49.02	N	27.22	N	19.19	3
20.48.20	♒	57.09½	N	39.20	N	20.12	3
1.16.20	♓	59.56	N	44.14	N	20.31	2
12.16.20	♒	64.28	N	44.27	N	19.32	3
29.06.20	♒	43.44	N	29.05	N	21.01	3

CASSIOPEIA.

3.40.50	♉	46.35	N	54.54	N	0.24	3
9.50.50	♉	48.46	N	59.04	N	0.40	3
13.44.20	♉	46.22	N	58.39	N	1.06	3
20.36.50	♉	47.29	N	62.10	N	1.33	3
0.58.50	♉	51.14	N	32.29	N	23.53	3

PERSEUS.

26.09.20	♉	34.30	N	52.25	N	2.45	3
27.40.20	♉	30.05	N	48.59	N	2.55	2
0.38.20	♊	27.14	N	46.46	N	3.22	3
22.00.00	♉	22.22½	N	39.45	N	2.49	3

AURIGA.

27.15.20	♊	21.27½	N	44.45	N	5.46	2
17.39.20	♊	22.50½	N	45.38	N	4.54	1
18 22.50	♊	5.20	N	28.21	N	5.07	2

OPHIUCUS.

In his Head, *Ras Alangue* — — — —
Uppermost in his Right Shoulder — — —
Lowermost in *ditto* — — — — —
Northern in the Left Hand, *Jed* — — —

SERPENS OPHIUCHI.

In the Upper Jaw — — — —
In the Temples — — — — —
In the Eduction of the Neck — — — —
Brightest in the middle of the Neck — — —
Antipenultimate in the Tayl — — — —
Penultimate — — — — —
Ultimate or last in the Tayl — — — —

AQUILA.

In the Neck — — — — —
Bright one near the Shoulder, *Alcair* — —
Next above it in the left Shoulder — —
In the Tayl — — — — —

ANTINOUS.

Northern in the Right Foot — — — —
In his Right Arm — — — — —
In his Right Knee — — — — —

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R.Ascen. H. M.	Magn.

SERPENTARIUS.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R.Ascen. H. M.	Magn.
18.13.20	♐	35.57	N	12.51	N	17.21	3
21.08.20	♐	28.01	N	4.45	N	17.29	3
22.28.20	♐	26.11	N	2.22	N	17.33	3
28.07.50	♏	17.19	N	2.53	S	15.59	3

The Serpent of OPHIUCUS.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R.Ascen. H. M.	Magn.
15.47.20	♏	39.06½	N	20.53	N	15.38	3
18.29.20	♏	35.25	N	16.45	N	15.43	3
15.44.20	♏	34.27½	N	16.27	N	15.32	3
17.53.20	♏	25.35	N	7.25	N	15.30	2
25.57.20	♐	19.57	N	3.31	S	17.45	5
1.35.20	♑	20.37	N	2.53	S	18.06	3
11.33.20	♑	26.59	N	3.54	N	18.41	3

The EAGLE.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R.Ascen. H. M.	Magn.
28.16.20	♑	26.49½	N	5.40	N	19.40	3
27.56.20	♑	29.21½	N	8.11	N	19.39	2
26.49.20	♑	31.18	N	9.56	N	19.32	3
15.38.20	♑	36.16	N	13.28	N	18.51	3

ANTINOUS.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R.Ascen. H. M.	Magn.
13. 9.20	♑	17.41	N	5.25	S	18.50	3
19.24.20	♑	24.56	S	2.37	N	19.10	3
20 40.20	♑	14.28	N	7.33	S	19 21	3

OPHIUCUS.

In his Head, *Ras Alangue* ———
Uppermost in his Right Shoulder ———
Lowermost in *ditto* ———
Northern in the Left Hand, *Jed* ———

SERPENS OPHIUCHI.

In the Upper Jaw ———
In the Temples ———
In the Eduction of the Neck ———
Brightest in the middle of the Neck ———
Antipenultimate in the Tayl ———
Penultimate ———
Ultimate or last in the Tayl ———

AQUILA.

In the Neck ———
Bright one near the Shoulder, *Alcair* ———
Next above it in the left Shoulder ———
In the Tayl ———

ANTINOUS.

Northern in the Right Foot ———
In his Right Arm ———
In his Right Knee ———

Longitude D. M. S.		Latitude D. M		Declin. D. M		R. Ascen H. M.	Magn.

SERPENTARIUS.

Longitude D. M. S.		Latitude D. M		Declin. D. M		R. Ascen H. M.	Magn.
18.13.20	♐	35.57	N	12.51	N	17.21	3
21.08.20	♐	28.01	N	4.45	N	17.29	3
22.28.20	♐	26.11	N	2.22	N	17.33	3
28.07.50	♏	17.19	N	2.53	S	15.59	3

The Serpent of OPHIUCUS.

Longitude D. M. S.		Latitude D. M		Declin. D. M		R. Ascen H. M.	Magn.
15.47.20	♏	39.06½	N	20.53	N	15.38	3
18.29.20	♏	35.25	N	16.45	N	15.43	3
15.44.20	♏	34.27½	N	16.27	N	15.32	3
17.53.20	♏	25.35	N	7.25	N	15.30	2
25.57.20	♐	19.57	N	3.31	S	17.45	5
1.35.20	♑	20.37	N	2.53	S	18.06	3
11.33.20	♑	26.59	N	3.54	N	18.41	3

The EAGLE.

Longitude D. M. S.		Latitude D. M		Declin. D. M		R. Ascen H. M.	Magn.
28.16.20	♑	26.49½	N	5.46	N	19.40	3
27.56.20	♑	29.21		8.11	N	19.39	2
26.49.20	♑	31.18	[illegible]	9.56	N	19.32	3
15.38.20	♑	36.16	N	13.28	N	18.51	3

ANTINOUS.

Longitude D. M. S.		Latitude D. M		Declin. D. M		R. Ascen H. M.	Magn.
13. 9.20	♑	17.41	N	5.15	S	18.50	3
19.24.20	♑	24.56	S	2.37	N	19.10	3
20.40.20	♑	14.28	N	7.33	S	19.21	3

CYGNUS.

In the Bill, *Albireo* —— ——— ——— — —
In her Breast——————————————
In her Tayl, *Arides*—————————————
First & brightest in the Bend of the higher Wing
Middlemost in the lower Wing ——— ————

CASSIOPEIA.

In her Breast, *Schedir*—————— ——— ———
In her Bending towards the Hip ——— ————
In her Knee——— ——— —————————
In her Leg ——— ——— ——— ————
Bright one in the Chair—————————————

PERSEUS.

In his Right Shoulder————————————
Bright one in his side, *Algenib* ——————————
Next in the Bend of his side-————————
Medusa's Head, *Algol* ————————————

AURIGA.

In his Right Shoulder——— ——— ——— ———
In his Left Shoulder, *Capella*- ——— ———
In his Right Foot- ——————————————

OPHI-

The SWAN.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R. Ascen. H. M.	Magn.
27.07.20	♑	49.02	N	27.22	N	19.19	3
20.48.20	♒	57.09½	N	39.20	N	20.12	3
1.16.20	♓	59.56	N	44.14	N	20.31	2
12.16.20	♒	64.28	N	44.27	N	19.32	3
29.06.20	♒	43.44	N	29.05	N	21.01	3

CASSIOPEIA.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R. Ascen. H. M.	Magn.
3.40.50	♉	46.35	N	54.54	N	0.24	3
9.50.50	♉	48.46	N	59.04	N	0.40	3
13.44.20	♉	46.22	N	58.39	N	1.06	3
20.36.50	♉	47.29	N	62.10	N	1.33	3
0.58.50	♉	51.14	N	32.29	N	23.53	3

PERSEUS.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R. Ascen. H. M.	Magn.
26.09.20	♉	34.30	N	52.25	N	2.45	3
27.40.20	♉	30.05	N	48.59	N	2.55	2
0.38.20	♊	27.14	N	46.46	N	3.22	3
22.00.00	♉	22.22½	N	39.45	N	2.49	3

AURIGA.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R. Ascen. H. M.	Magn.
27.15.20	♊	21.27½	N	44.45	N	5.46	2
17.39.20	♊	22.50½	N	45.38	N	4.54	1
18.22.50	♊	5.20	N	28.21	N	5.07	2

OPHIUCUS.

In his Head, *Ras Alangue* ——————
Uppermost in his Right Shoulder ——— ——
Lowermost in *ditto* ——— ——— ——
Northern in the Left Hand, *Jed* ——— ———

SERPENS OPHIUCHI.

In the Upper Jaw ——————— ————
In the Temples ——————————
In the Eduction of the Neck ————————
Brightest in the middle of the Neck ————
Antipenultimate in the Tayl ——————
Penultimate ———————————
Ultimate or last in the Tayl ——————

AQUILA.

In the Neck ———————————
Bright one near the Shoulder, *Alcair* ————
Next above it in the left Shoulder ————
In the Tayl ———————————

ANTINOUS.

Northern in the Right Foot ——————
In his Right Arm ——————————
In his Right Knee ——————————

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R.Ascen H. M.	Mag.

SERPENTARIUS.

18.13.20	♐	35.57	N	12.51	N	17.21	3
21.08.20	♐	28.01	N	4.45	N	17.29	3
22.28.20	♐	26.11	N	2.22	N	17.33	3
28.07.50	♏	17.19	N	2.53	S	15.59	3

The Serpent of OPHIUCUS.

15.47.20	♏	39.06½	N	20.53	N	15.38	3
18.29.20	♏	35.25	N	16.45	N	15.43	3
15.44.20	♏	34.27½	N	16.27	N	15.32	3
17.53.20	♏	25.35	N	7.25	N	15.30	2
25.57.20	♐	19.57	N	3.31	S	17.45	3
1.35.20	♑	20.37	N	2.53	S	18.06	3
11.33.20	♑	26.59	N	3.54	N	18.41	3

The EAGLE.

28.16.20	♑	26.49½	N	5.46	N	19.40	3
27.56.20	♑	29.21½	N	8.11	N	19.39	2
26.49.20	♑	31.18	N	9.56	N	19.32	3
15.38.20	♑	36.16	N	13.28	N	18.51	3

ANTINOUS.

13.[illegible]9.20	♑	17.41	N	5.15	S	18.50	3
19.24.20	♑	24.56	S	2.37	N	19.10	3
20.40.20	♑	14.28	N	7.33	S	19.21	3

DELPHINUS.

Bright Star of the Tayl
First Star in the Rhomb
Second in the same side
Third
Fourth

PEGASUS.

In the Mouth, *Enif*
Brightest in the Neck
Bright one in the Right Knee
First Star in the Wing, *Marchab*
In the Thigh, *Scheat*
End of the Wing

ANDROMEDA.

In her Head
Northern and brightest in the Left Shoulder
Southern and brightest in her Girdle, *Mirach*
Bright one in the South Foot, *Alamech*

Northern Constellations.

ARIES.

Bright Star in the top of the Head

TAURUS.

South Eye, *Aldebaran, Palilitium*
North Eye
End of the South Horn

GEMIN

Longitude D. M. S.		Latitude D. M.		Declin. D. M		R. Ascen. H. M.	Magn.

The DOLPHIN.

9.55.20	♒	29.08	N	10.20	N	20.18	3
12.19.20	♒	31.57½	N	13.36	N	20.24	3
13.13.50	♒	33.05	N	14.54	N	20.26	3
14.59.50	♒	32.00	N	14.18	N	20.33	3
15.15.20	♒	32.47	N	15.06	N	20.33	3

PEGASUS.

27.45.20	♒	22.07½	N	8.31	N	21.30	3
12.02.50	♓	17.41	N	9.47	N	22.27	3
21.33.20	♓	35.07½	N	28.35	N	22.28	3
19.19.50	♓	19.26	N	13.38	N	22.50	2
25.12.20	♓	31.07	N	26.27	N	22.49	2
5.01.20	♈	12.35	N	13.31	N	23:58	2

ANDROMEDA.

10.10.20	♓	25.42	N	27.27	N	23.52	2
17.42.50	♈	24.20	N	29.14	N	00.24	3
25.42.20	♈	25.59	N	33.52	N	00.51	2
10.02.20	♓	27.46½	N	40.52	N	01.46	2

ARIES. ♈

3.29.20	♉	9.57	N	22.02	N	01.50	3

TAURUS. ♉

5.35.50	♊	5.31	S	15.42	N	04.19	1
4.16.20	♊	2.36½	S	18.38	N	04.12	3
20.35.20	♊	2.14	S	20.55	N	05.21	3

GEMINI.

In the Head of *Castor*, *Apollo* — — — — — —
In the lower Head, *Pollux* — — — — — —
In the Left Knee — — — — — —
First in the Foot of *Castor* — — — — — —
Bright one in the Foot of *Pollux* — — — — —

CANCER.

In the Breast, *Præsepe* — — — — — —
In the South Claw — — — — — —

LEO.

Middle bright one in the Neck, *Alezet* — —
Lyon's Heart, *Basiliscus*, *Regulus* — — — —
Lyon's Back — — — — — — — —
Bright Star in his Tayl, *Deneb* — — — — —

VIRGO.

Brightest in the Northern Wing, *Vindemiatrix* —
The Virgin's Spike, *Azimech* — — — — —
In the end of the South Wing — — — —

Southern Constellations.

LIBRA.

Bright one in the South Scale, *Zubenelgemubi* — —
In the Fulciment of the Beam, *Zubenesch-amali* —
First of the three in the North Scale — — —

SCOR-

Longitude D. M. S.		Latitud. D. M.		Declin. D. M.		R. Ascen H. M.	Magn.
GEMINI. ♊							
16.04.20	♋	10.0	N	32.29	N	07.16	2
19.06.20	♋	6.38	N	28.43	N	07.27	2
5.45.5	♋	2.11	N	25.30	N	06.26	3
29.21.20	♊	0.58	S	22.32	S	06.03	3
05.54.20	♋	6.48	S	16.38	S	06.20	2
CANCER. ♋							
03.09.50	♌	1.14	N	20.35	N	08.23	4
09.26.50	♌	5.08	S	12.59	N	18.42	3
LEO. ♌							
25.22.20	♌	8.47	N	21.20	N	10.03	2
25.40.20	♌	0.26	N	13.26	N	09.52	1
7.04.20	♍	14.20	N	22.44	N	11.02	2
17.26.20	♍	12.18	N	16.16	N	11.34	1
VIRGO. ♍							
5.46.20	♎	16.15	N	12.36	N	12.48	3
19.39.20	♎	1.59	S	9.32		13.10	1
22.55.20	♍	0.43	N	3.28	N	11.35	3
LIBRA. ♎							
10.54.20	♏	0.26	N	14.36	S	14.35	2
15.11.20	♏	8.35	N	8.12	S	15.01	2
20.56.20	♏	4.28	N	13.42	S	15.19	3

SCORPIO.

North bright one in the Front ————————
Second in the Front ————————
Third in the Front ————————
Scorpion's Heart, *Antares* ————————

SAGITTARIUS.

In the Southern part of his Bow ————————
In his Left Shoulder- ————————

CAPRICORNUS.

First bright one in the Tayl, *Deneb Algeni* ————
Second bright one in the Tayl ————————

AQUARIUS.

Brightest in his Left Shoulder ————————
Brightest in his Right Shoulder ————————
South in the right Shank, *Scheat* ————————
The last in the Effusion, *Fomahant* ————

PISCES.

South of the two in the Head ————————
First of the 3. Bright ones in the South Line- ——
Middlemost of them three- ————————
Middle and bright one of the Knot- ————————

CETE.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R. Ascen. H. M.	Magn.

SCORPIO ♏

28.59.20	♏	1.05	N	18.53	S	15.48	3
28.23.10	♏	1.54½	S	21.50	S	15.43	3
28.45.10	♏	5.22½	S	25.10	S	15.42	3
5.32.10	♐	4.27	S	25.40	S	16.11	1

SAGITTARIUS. ♐

0.52.10	♑	10.55	S	34.25	S	18.4	3
8.10.10	♑	3.23	S	26.38	S	18.37	3

CAPRICORNUS. ♑

17.37.20	♒	2.26	S	17.56	S	21.28	3
19.23 20	♒	2.29	S	17.27	S	21.31	3

AQUARIUS. ♒

19.12.50	♒	8.42	N	6.56	S	21.16	3
29.12.50	♒	10.42	N	1.44	S	15.10	3
4.45.20	♓	8.10	S	17.22	S	22.39	3
29.34.50	♒	21.00	S	31.09	S	22.41	1

PISCES. ♓

17.13 50	♓	7.17½	N	1.32	N	16.22	4
9.59.20	♈	2.11	N	5.58	N	0.33	4
13.21.20	♈	1.05	N	6.17	N	0.48	4
22.39.20	♈	5.21	N	19.48	N	1.16	4

CETE

CETE.

Bright ✳ in her Tayl, South, *Deneb Kaitos* ———
North in the Tayl ——————————
North in the Belly, *Beten Kaitos* ————
In the Jaw, *Menchar* ————————

ORION.

In his Right Shoulder, *Bed Algense* ————
In his Left Shoulder ——————————
Northern and first in his Belt ——————
Middlemost ————————————
Last in the Belt ——————————
In his Left Foot, *Rigel, Algebar* ————

LEPUS.

In the Left Foot ——————————
Near the Back ———————————
Southern of the two in the Hind Feet ——
Northern of the two there ——————

ERIDANUS.

Above the Foot of *Orion* in the River ——
First of the 3 in a Right Line with *Menchar* ——
Last in the River *Achernar* ————————

CANIS Minor.

Brightest in the Neck ———————
Bright one in his Thigh, *Procyon, Alschere* ——

CANIS

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R. Ascen. H. M	Magn.

The WHALE.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R. Ascen. H. M	Magn.
28.19.20	♓	20.47	S	19.39	S	00.28	2
26.46.20	♓	10.01	S	10.28	S	00.04	3
17.48.20	♈	20.19	S	11.46	S	01.37	3
10.10.20	♉	12.37	S	2.55	N	03.23	2

ORION.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R. Ascen. H. M	Magn.
24.35.20	♊	16.06	S	7.18	N	5.39	2
16.46.20	♊	16.53	S	6.02	S	5.09	2
18.13.50	♊	23.38	S	0.35	S	5.17	2
19.17.20	♊	24.33½	S	1.25	S	5.21	2
20.29.50	♊	25.21⅓	S	2.08	S	5.25	2
12.40.20	♊	31.11	S	8.35	S	5.00	1

The HARE.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R. Ascen. H. M	Magn.
15.29.50	♊	43.57	S	21.01	S	5.16	3
17.12.50	♊	41.05½	S	18.02	S	5.24	3
20.44.50	♊	45.49½	S	22.32	S	5.32	3
22.59.20	♊	44.18	S	20.56	S	5.39	3

River ERIDANUS.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R. Ascen. H. M	Magn.
11.05.20	♊	27.54½	S	5.30	S	4.53	3
19.41.20	♉	33.13	S	14.21	S	3.44	3
10.50.10	♓	59.18½	S	58.57	S	1.23	1

Little DOG.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R. Ascen. H. M	Magn.
18.02.50	♋	13.33½	S	8.51	N	7.11	3
21.41.50	♋	15.57	S	6.00	N	7.24	2

Great

CANIS Major.

Brighteſt in his Mouth, *Syrius*- ——— ———
In the end of the Fore-Foot— ——— ——— ———

COLUMBA NOACHI.

Former of the two Bright ones- ——— ——— ———
The following bright one ——— ——— ——— ———

ARGO.

Bright ✱ upon the Deck, near the Mizzen-Maſt
Next bright one almoſt in a right line- ———
Southern of the 4 bright ones in the Hull———
Next bright one neareſt the *Royal-Oak*- ———
Northern of the 4 bright ones there——— ———
Canobus, or brighteſt in the Stern, *Schemuel*———

ROBUR CAROLINUM.

At the Root thereof ——— ——— ——— ———
At the top of the Trunk-——— ———

HYDRA.

Hydra's Heart, *Alphard*——— ——— ———
Firſt in the *Weſtern* Triangle ——— ——— ———

COR-

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R. Ascen. H. M.	Magn.

Great DOG.

9.58.50	♋	39.30	S	16.17	S	6.32	1
3.05.50	♋	41.18½	S	17.48	S	6.10	2

NOAH's DOVE.

18.06.10	♊	57.24	S	34.24	S	5.29	3
22.20.40	♊	59.15	S	35.54	S	5.41	3

The SHIP.

23.09.10	♌	64.26¼	S	46.24	S	8.0	2
14.41.10	♍	67.11	S	53.33	S	8.36	2
18.53.10	♍	72.40	S	58.29	S	8.16	2
0.34.10	♎	67.06	S	57.30	S	9.06	2
24.39.10	♍	63.43	S	53.41	S	9.12	2
10.51.10	♋	75.48	S	52.28	S	6.18	1

The ROYAL-OAKE.

27.44.10	♎	72.15½	S	68.26	S	9.09	2
24.56.10	♎	62.10	S	62.48	S	10.31	3

HYDRA.

23.08.50	♌	22.24	S	7.23	S	9.11	1
3.52.10	♎	31.31	S	30.07	S	11.22	3

The

CORVUS.

Former of the higher in the □ of her Wing ——
The following ✳ in the other W. & in □ *Algorab*
The following of the lower, in the Square ——

CENTAURUS.

Following of the two in his Loyns —— ——
First in the Crosiers —— —— —— ——
Northern in the Crosiers —— —— —— ——
Southern in the Crosiers —— —— —— ——
Last in the Crosiers —— —— —— ——
In the left Knee —— —— —— ——
In the right Foot —— —— —— ——

LUPUS.

In the Foot near the *Centaur*'s Head —— ——
In the Knee of the other hinder Foot —— ——

ARA.

In the middle of the Altar —— —— —— ——

GRUS.

In the Head —— —— —— —— ——
Bright ✳ in the left Wing —— —— ——
In the Eduction of her Tayl —— —— ——

PHÆ-

The CROW.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R.Ascen. H. M.	Magn.
6.36.20	♎	14.25	S	16.07	S	11.57	3
9.18.20	♎	12.07	S	14.48	S	12.15	3
13.12.20	♎	17.57	S	21.42	S	12.19	3

The CENTAUR.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R.Ascen. H. M.	Magn.
28.12.10	♎	40.03	S	47.17	S	12.24	2
1.34.10	♏	50.18	S	57.02	S	12.00	3
2.35.10	♏	47.41	S	55.21	S	12.15	2
7.45.10	♏	52.45	S	61.22	S	12.12	2
7.31.10	♏	48.29	S	57.45	S	12.37	2
18.37.10	♏	44.00	S	58.49	S	13.43	2
25.44.10	♏	42.23	S	59.30	S	14.20	1

The WOLF.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R.Ascen. H. M.	Magn.
20.50.10	♏	24.56½	S	41.50	S	14.39	3
19.19.10	♏	29.54	S	46.00	S	14.22	3

The ALTAR.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R.Ascen. H. M.	Magn.
20.42.40	♐	26.25½	S	49.33	S	17.09	3

The CRANE.

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R.Ascen. H. M.	Magn.
13.14.10	♒	22.55½	S	38.39	S	21.36	3
11.39.20	♒	32.47	S	48.23	S	21.49	2
18.00.10	♒	35.20	S	48.25	S	22.24	2

The

PHŒNIX.

Bright ſtar in the Neck
In the Pynion of her right Wing
In the ſide of the left Wing

PAVO.

Peacock's Eye
In his Breaſt

INDUS.

Near the end of his Arrow

TOUCAN.

In the end of the Bill
In the Head

HYDRUS.

In the Eye near *Acharnar*
Following of the two between the Clouds
The preceeding

TRIANGULUM AUSTRALE.

Southern in the Baſe
In the Vertex
Northern in the Baſe

Longitude D. M. S.		Latitude D. M.		Declin. D. M.		R.Ascen H. M.	Magn.
The PHŒNIX.							
11.10.10	♓	40.33	S	43.49	S	0.19	2
5.20.10	♓	41.53½	S	47.24	S	23.53	3
23.48.10	♓	47.34	S	44.36	S	1.18	3
The PEACOCK.							
19.37.40	♑	36.06½	S	57.33	S	20.01	2
24.18.10	♑	46.51½	S	66.34	S	21.00	3
The INDIAN.							
14.59.20	♑	32.35	S	54.56	S	19.29	3
TOUCAN.							
5.14.10	♒	45.24	S	61.50	S	22.11	3
16.06.40	♒	47.45½	S	59.51	S	23.00	3
HYDRUS.							
7.33.10	♓	64.09½	S	63.10	S	1.47	3
6.01.10	♒	76.48	S	75.06	S	2.07	3
26.24.10	♑	64.27	S	78.57	S	0.14	3
The Southern Triangle.							
5.13.10	♐	47.57	S	67.27	S	14.52	3
16.39.10	♐	46.00	S	68.19	S	16.17	3
7.42.10	♐	41.46	S	62.23	S	15.29	3

The use of the foregoing Tables.

Of the Sun's Declination.

THE Declination of the Sun is nothing else but an Arch of the Meridian intercepted between the Equator and the Sun, as I have observed to you in *Chap.* 1. and seeing the Sun has a different Declination every day (except when he is under the Equator) this Declination must be continually encreasing or decreasing from what it was the day before; therefore it happens that in places lying much to the Eastward or Westward of any Meridian (suppose that of *London*) the Declination of the Sun at these places shall be different from what it was at the Meridian of *London*, the same day: Then to find this difference of Declination of the Sun, observe this following Rule.

To find the Sun's Declination by these Tables.

By any Ephemeris for the Year you observe in, find the Suns true place, or degree of the Sun in the Ecliptic, with which enter the Table, entituled a Table of the Suns Declination and Right Ascension, in which against the place of the Sun (found in the Ephemeris) you have the Suns Right Ascension and Declination.

E X-

EXAMPLE 1.

May 24. 1695. I demand the Suns Right A-
ſion and Declination. By an Ephemeris for
s Year, I find the Sun to be in ♊ 13°. againſt
ich in the Tables of Declination ſtand 22° 25'
the Suns true Declination that day, and 4 H.
M. for his Right Aſcenſion the ſame day.

EXAMPLE 2.

May 7, 1695. The Sun is in ♉, 26°. 44'. I
and his Declination. Find the Suns Declina-
for ♉ 26, which is 19°. 18'. And alſo for
which is 19°. 32'. the difference between
e two numbers is 14'. Then ſay,
If 60' require 14', what ſhall 44' require? An-
r 10'. which added to 19°. 18'. the Sum 19°.
is the Declination required.
And thus you may proceed for any other num-
of Degrees and Minutes in the Suns place.
d in like manner may his Right Aſcenſion be
d.

find the difference of the Suns Declination under any two Meridians on the ſame Day.

Let the two places be *London* and *Surrat*, whoſe
ference of Longitude is about 90°. *Surrat* lying
ward of *London*.

Because the difference of Longitnde is 90°. o
6 H. therefore it is evident when the Sun is up
on the Meridian at *London*, it 6 is a Clock After
noon at *Surrat*, for the Sun spends six whole hou
in passing from the Meridian of the one, to th
Meridian of the other; in which quantity o
time there is a sensible difference in the Suns De
clination, and may be found by this

General RULE.

Find the difference of the Suns Declination be
tween the day given and the day following, tha
is (as in this Example) between *May* 7. an
May 8. for *May* 7. the Suns Declination is 19
28'. and for *May* 8. it is 19°. 37'. Then subtra
19°. 28' from 19°. 37'. the remainer 9'. is the dif
ference of the Suns Declination for one day
Therefore 4 ½ Minutes will be the difference o
the Suns Declination for half a day, or 12 hours
and 2 ¼ Minutes for 6 hours. Hence it is evident
that supposing the Suns Declination to be 19°. 28
at *Surrat May* 7. it will be 19°. 30' ¼ at *London* six
hours after.

The

[Th]e use of the Astral Table for finding the time of the Night.

RULE.

TO the Complement of the Suns Right Ascension add the Right Ascension of the [Sta]r, the Sum is the true time of that Stars [Sou]thing.

EXAMPLE.

March 27. 1695. The Suns place is 17°. and [its] Right Ascension, by the foregoing Table, is [1 H.] 03 M. I demand what time *Castor* comes to [the] Meridian?

By the Tables I find the Right Ascension of [*Cas*]*tor* is 7 H. 16 M. and the Complement of the [Sun]s Right Ascension that day is 22° 57'. There-[fore]

H. M.
to — 22.57'
add — 7.16
30.13
24.00
6.13

Answer. *Castor* comes to the Meridian at [illegible] Clock 13 Minutes past in the Evening.

Note. If the Sum of the Stars Right Ascen[sion], and Complement of the Suns Right Asce[n]sion exceed 12 or 24 Hours, subtract 12 or [24] from this Sum, and the remainer shall be the ti[me] of the Stars Southing.

A Tabl[e]

Diff.	¼ Point.		½ Point.		¾ Point.		1 Point.		Diff.
	Latit.	Dep.	Latit.	Dep.	Latit.	Dep.	Latit.	Dep.	
1	09988	0491	09952	00980	09892	01466	09808	01951	1
2	19976	00981	19903	01960	19784	02933	19616	03502	2
3	29964	01472	29855	02541	29675	04402	29424	5853	3
4	39952	01953	39807	03921	39567	05865	39232	7804	4
5	49949	02454	4974	04901	49459	07337	49040	09755	5
6	59927	02944	59711	05881	58351	08804	58847	11705	6
7	69915	03435	69663	06851	68243	10271	68654	13656	7
8	79903	03525	79615	07842	78134	11738	78463	15607	8
9	89891	04416	89557	08822	88026	13206	88271	17558	9
10	99879	04097	99515	09802	98918	14673	98075	19509	10
	Dep.	Latit.	Dep.	Latit.	Dep.	Latit.	Dep.	Latit.	Diff.
	7¾ Points.		7½ Points.		7¼ Points.		7 Points.		

Diff.	1¼ Point.		1½ Point.		1¾ Point.		2 Points.		Diff.
	Latit.	Dep.	Latit.	Dep.	Latit.	Dep.	Latit.	Dep.	
1	09700	2430	09569	02903	09415	03375	09235	03827	1
2	19400	04860	19135	05806	18830	06738	18478	07654	2
3	29101	07289	28708	0870	28245	10107	27716	11481	3
4	38801	07915	38277	11612	37650	13476	39055	15308	4
5	48501	12145	47845	1451	47075	16845	46194	19185	5
6	58201	145 5	57419	17418	56491	20214	55433	22902	6
7	67901	17005	66984	20321	590	23583	4672	25785	7
8	77602	10428	76554	23224	75323	26952	73910	30616	8
9	87302	21868	85124	2612	84233	30321	83149	34443	9
10	97002	24298	5504	26030	94154	33	2388	38270	10
	Dep.	Latit.	Dep.	Latit.	Dep.	Latit.	Dep.	Latit.	Diff.
	6¾ Points.		6½ Points.		6¼ Points.		6 Points.		

Dist.	2 1/4 Points.		2 1/2 Points.		2 3/4 Points.		3 Points.		Dist.
	Latit.	Dep.	Latit.	Dep.	Latit.	Dep.	Latit.	Dep.	
1	05040	04276	08815	04714	08577	05141	08315	05560	1
2	8080	08552	17638	09428	17154	10282	16630	11112	2
3	27120	12828	26457	14142	25731	15423	24945	16668	3
4	36160	17104	35276	18856	34308	20564	33260	22224	4
5	45200	21380	44095	23570	42885	25705	41574	27780	5
6	54240	25656	52914	28282	51462	30846	49890	33336	6
7	63280	25932	61733	32998	60039	35987	58205	38892	7
8	72320	34208	70552	37712	58616	41128	66520	44448	8
9	81360	38484	79371	42426	77191	46269	7483[illegible]	50004	9
10	[illegible]0100	42760	88190	47140	85758	51410	83150	55560	10
Dist.	Dep.	Latit.	Dep.	Latit.	Dep.	Latit.	Dep.	Latit.	Dist.
	5 1/4 Points.		5 1/2 Points.		5 3/4 Points.		5 Points.		

Dist.	3 1/4 Points.		3 1/2 Points.		3 3/4 Points.		4 Points.		Dist.
	Latit.	Dep.	Latit.	Dep.	Latit.	Dep.	Latit.	Dep.	
1	08032	0595	07730	06344	07410	06716	07071	07071	1
2	1606	11914	15460	12688	14820	13432	14142	14142	2
3	2409	17871	23190	19032	22230	20148	21213	21212	3
4	32128	23828	3[illegible]20	25376	2964[illegible]	26864	2828[illegible]	28284	4
5	40160	2078[illegible]	[illegible]	[illegible]	[illegible]	2258[illegible]	[illegible]	[illegible]	5
6	4819	[illegible]742	46380	38[illegible]64	4446	40296	42426	4242[illegible]	6
7	5622	[illegible]	54110	44408	[illegible]	47012	4949[illegible]	4949[illegible]	7
8	4256	47656	[illegible]	[illegible]	59280	[illegible]	[illegible]6568	[illegible]6568	8
9	2288	53613	[illegible]	[illegible]	56691	[illegible]0444	[illegible]	64639	9
10	[illegible]	[illegible]	[illegible]	6244[illegible]	[illegible]	[illegible]	[illegible]	70[illegible]1	10
Dist.	Dep.	Latit.	Dep.	Latit.	Dep.	Latit.	Dep.	Latit.	Dist.
	4 3/4 Points.		4 1/2 Points.		4 1/4 Points.		4 Points.		

The Use of the Table of Difference of Latitude and Departure.

EXAMPLE 1.

A Ship Sails NEBN 8 *Miles. I demand her Difference of Latitude and Departure.*

THis Course is 3 Points distant from the N°. therefore find 3 Points in the Table, and against 8 (under the Column of Distance) stand 6.6520 Miles for the difference of Latitude, and 4.4448 Miles for the Departure; where observe, That the first Figures towards the left hand, signifie Miles, and the other Figures towards the right hand signifie ten thousand parts of a Mile.

EXAMPLE 2.

A Ship Sails NEBN. 8 *Miles, or* $\frac{8}{10}$ *of a Mile. I demand her difference of Latitude and Departure.*

Here we find the same Numbers as afore but with this difference, *viz.* because the distance run is less than a Mile, (and is ever the greatest side in a right angled Triangle) therefore the diffe ence

difference of Latitude and Departure will each of them be less than one mile: As in this Case, the difference of Latitude is .66520, or sixty six thousand five hundred and twenty hundred thousand parts of a mile, and the Departure .44448, or forty four thousand four hundred and forty eight hundred thousand parts of a mile.

EXAMPLE 3.

A Ship Sails NEBN 80 *Miles. I demand her Difference Latitude and Departure.*

In this Case you must note, That each of the Numerical Figures under the Column of distance, signifie 10, 20, 30, &c. and consequently 8 must signifie 80; then must the difference of Latitude and Departure consist of two Figures, and the other remaining Figures which stand on the right hand of these, will be thousand parts of a mile: And thus it appears that the difference of Latitude is 66. 520 miles, or 66 miles and 520 thousand parts of a mile, and the Departure 44.448, or 44 miles and 448 thousand parts of a mile.

EXAMPLE 4.

A Ship Sails NEBN 800 *Miles.*

Here the Numerical Figures under the Column of Distance signifie hundreds; thus, 1, 2, 3, &c. must be accounted 100, 200, 300, &c. miles, and consequently 8 (in the same Column) must signifie eight hundred miles; and therefore seeing the Distance

Distance run consists of 3 Figures (each Number in the Table consisting of 5) the difference of Latitude and Departure must each consist of 3 Figures; then it is evident that in this Example the difference of Latitude is 665.20, or 665 miles and 20 hundred parts of a mile, and the Departure 444.48 or 444 miles, and 48 hundred parts of a mile. Lastly, If the distance run had been 8000 miles, the difference of Latitude would have been 6652 miles, and the Departure 4444.8 miles, or 4444 miles, and 8 tenths of a mile more.

EXAMPLE 5.

A Ship Sails SSE 74 *Miles. I demand her Difference of Latitude and Departure.*

In this Case you must break the distance run into two parts: Namely 70 and 4, then it is evident from Example 3d. that if the distance run be 70 miles the Diff. Latit. will be 64 miles and 672 thousand parts of a mile, and that the Departure will be 26 miles and 788 thousand parts of a mile. Again by Examp. 1. If the distance run be 4 miles, Diff. Latit. will be 3 miles and 9232 ten Thousand parts of a mile; also the Departure will then be 0 mile, and 7804 ten thousand parts of a mile: But 64.672 miles added to 3.9232 miles make 68 miles, and 5952 ten thousand parts of a mile for the difference of Latitude required; and 26.788 added to 0.7804 make 27 miles and 5684 ten thousand parts of a mile for the Departure required. Therefore it is evident that the difference of Latitude in this Example is 68.5952 miles, or 68.6 mile

miles almost, and that the Departure is 27.5684 miles, or 27. $\frac{2}{18}$ miles, and somewhat more.

EXAMPLE 6.

A Ship Sails WSW 123 *Miles. I demand her Difference of Latitude and Departure.*

Here the distance run must be broke into 3 parts (because it consists of 3 places) namely 100. 20. and 3. then by Examp. 4. it appears that if the distance run be 100 miles, the diff. of Latit. will be 38.270 miles, and the Departure will be 92.39c miles. Also by Examp. 3. it is evident, that if the distance run be 20 miles, the diff. of Latit. will be 0.7.645 miles, and the Departure 18.478 miles. Lastly from Examp. 1. it is apparent that if the Distance run be 3 miles, the difference of Latit. will be 1.1480 mile, and the Departure 2.7716 miles: Write down all these particular differences of Latit. and Depart. exactly under one another, as here you see them exprest.

Diff. Lat.		Depart.
38.270	——	92.390
07.654	——	18.478
1.1480	——	2.7716
47.0720	——	113.6396

And

And thus it appears that the difference of Latitude is 47 miles and .0720 ten thousand parts of a mile, and the Departure is 113 miles and 6396 ten thousand parts of a mile.

The Use of the Table of Logarithms, and the Tables of Artificial Sines, Tangents and Secants.

1. IN the Table of Logarithms you find the round or absolute Numbers beginning at 1, and continued to 1000 are placed under the Letter N, and against each of these absolute numbers stands the responding Logarithm.

Thus the Logarithm of 8 is 090309. the Logarithm of 80 is 190309. and the Logarithm of 800 is 290309. So that these Logarithmical number differ only in the first Figure which is called the Characteristic. And thus may the Logarithm of any absolute number between 1 and 1000 be found by inspection.

2. *To find the Logarithm of any number greater than* 1000.

Here you must note, that the Characteristic of the Logarithm answering to the absolute number 10. the Characteristic of 10 is 1. of 100 is 2. of 1000 is 3. of 10000 is 4. of 100000 is 5. &c.

Then

Then let it be required to find the Logarithm of 87654. here the Characteristic will be 4. and consequently the Logarithm of 80000 is 490309. But because this Table is continued only to 1000. take the Logarithm of the first 3 Figures, *viz.* of 876. which is put to signifie 87600. and the Logarithm thereof is 494250. By the same Method find the Logarithm of 87700 which is 494300, Subtract 494250 from 494300 the remainer is 50. Also subtract 87600 from 87700; the remainer is 100. Then say

If 100 require 50, what shall 54 require.

50

2700

Answer 27, which added to 494250, the sum 494277 is the Logarithm answering to the absolute Number 87654. And thus may any other Logarithm be found answerable to any absolute Number exceeding 1000.

3. *To find the absolute Number answering to any given Logarithm.*

If the given Logarithm be found exactly in the Table, then the Figure or Figures in the Column N (which stand against this given Logarithm) gives the absolute number required.

But if the given Logarithm cannot be exactly found in the Table, seek for the nearest number which is less than the given Logarithm: then subtract this nearest less number from the given Logarithm, the remainer shall be the Numerator of the Fraction required, and the Denominator of that

hat Fraction is the Tabular difference between he nearest less, and the nearest greater Logarithm.

Let it be required to find the absolute number to this given Logarithm 155754.

The nearest less in the Table is 155630, which is the Logarithm of 36, the diff. between the Logarithm given and that in the Table is 124. the Numerator.

The nearest greater in the Table is 156820, diff. between this and the nearest less is 1190, which is the Denominator required, therefore, the true or absolute number answering to the given Logarithm is $361\frac{124}{1190}$.

The use of the Table of Artificial Signes, Tangents and Secants (which are no more than the Logarithms of the natural Sines Tangents and Secants) may be easily apprehended from the preceeding Rules.

To find how much Powder is sufficient both for Action and Proof of any Piece of Ordinance.

RULE.

Multiply the weight of the Ball by the Calibers in the Circumference of the Breech, and for Proof multiply this Product by 8. for Service multiply the same by 6. this last Product divided by 96 gives the number of Pounds of Powder.

EX-

EXAMPLE.

Let there be an Iron Ball weighing 24 *l.* fit for a Gun whose Breech contains 9 Calibers or Diameters of the Bore in Circumference,

I demand the quantity of Powder fit for Proof and Action.

Ball 24 *l.*	24 *l.*
Calib. 9	9
216	216
8	6
96)1728(18 *l.* Proof	96)1296(13 *l.* ½ Service or Action.
96	96
768	336
768	288
	48

This Rule is Short, and easie to be remembred, nor is there any difficulty in the Operation. We have many Authors who spend much pains in the delivery of this Proposition, to small Purpose; here you have the Rule in a few words, use it, or those delivered by others, and let your Experience commend it to you.

TO

To find the Tunnage of a Ship.

Multiply the length of the Keal, by the [br]eadth of the Midship beam, and that Product [b]y the depth of the Hold; Divide this number [by] 100, the Quotient gives the Tunnage for [Ma]n of War, and the same Product divided by [94] gives the Tunnage for Merchants Ships. [This] Rule so easy and plain needs no Example.

To find the Prime or Golden Number.

To the given Year of our Lord add 1. divide [tha]t Summ by 19, the remainer is the Prime re[qu]ired. If there be no remainer, then shall 19 [b]e the Prime that Year.

To find the Epact.

Multiply the Prime for the given Year by 11. [D]ivide that Product by 30, the remainer shall be [th]e Epact. If nothing remain the Epact is 30.

To find the Moon's Age.

Add the Epact, the number of the Months [fr]om *March*, and the day of the Month given [in]clusively, and if the Summ of these 3 numbers [b]e less then 30, it shall be the Age of the Moon, [i]f greater subtract 30 from it, and the remainer [i]s the Age required.

EXAMPLE.

June 24. 1695., *I demand the Moon's Age.*

1695	5	Epact
1	11	day of the Month.
19)1696(89	3|5|5|1	Months from *March*
152	|2|0|	
176	Spct. 25	
171		
		Moon's Age
Prime. 5		

To find the hour of the Moon's Culminating or coming upon the Meridian.

Multiply the Moon's Age by 4. divide th Product by 5. the Quotient is the time of t Moon's Southing, or coming upon the Meridia

Note that between the New and Full Moon sh comes South in the Evening, but after the Fu Moon, in the Morning.

The nearest Estimate of the Moon's Risin and Setting. At the New Moon she Riseth an Setteth with the Sun. At the Full, she Riset when the Sun Setts, and Setts at Sun-Rise.

At the beginning of her Encrease she Riset after-Sun Rise, and Setteth after Sun-Set.

A

At the beginning of her Decrease she Riseth a little after Sun-Sett, and Setts a little after Sun Rise.

At her first Quarter she Riseth about Noon and Setts about Midnight.

Lastly, She Riseth every $\frac{4}{5}$ of an hour later than she did the day before, which is the reason that you multiply her Age by 4, and divide that Product by 5 to find the time of her coming to the South.

To find the time of high Water.

To the Moon's Southing add the time of full Sea in that Place where you desire the time of high Water, and that sum shall be the Answer.

Thus at *London* when the Moon comes NE or SW (which answereth to 3 hours being 45°. from the Meridian) it is full Sea; to which add the time of the Moon's Southing, the Total is the time of high Water required.

He that desires to improve his Knowledg further in the use of the Calender may consult *Clavius* his Computum Ecclesiasticum. *De Chales* his Mundus Mathematicus. Dactylismum Ecclesiasticum Pomp. Lempei, and *Joannes Jocobus* in his Syn. Mathemat. where he will not only find the Rules, but the Reason of them explained.

FINIS.